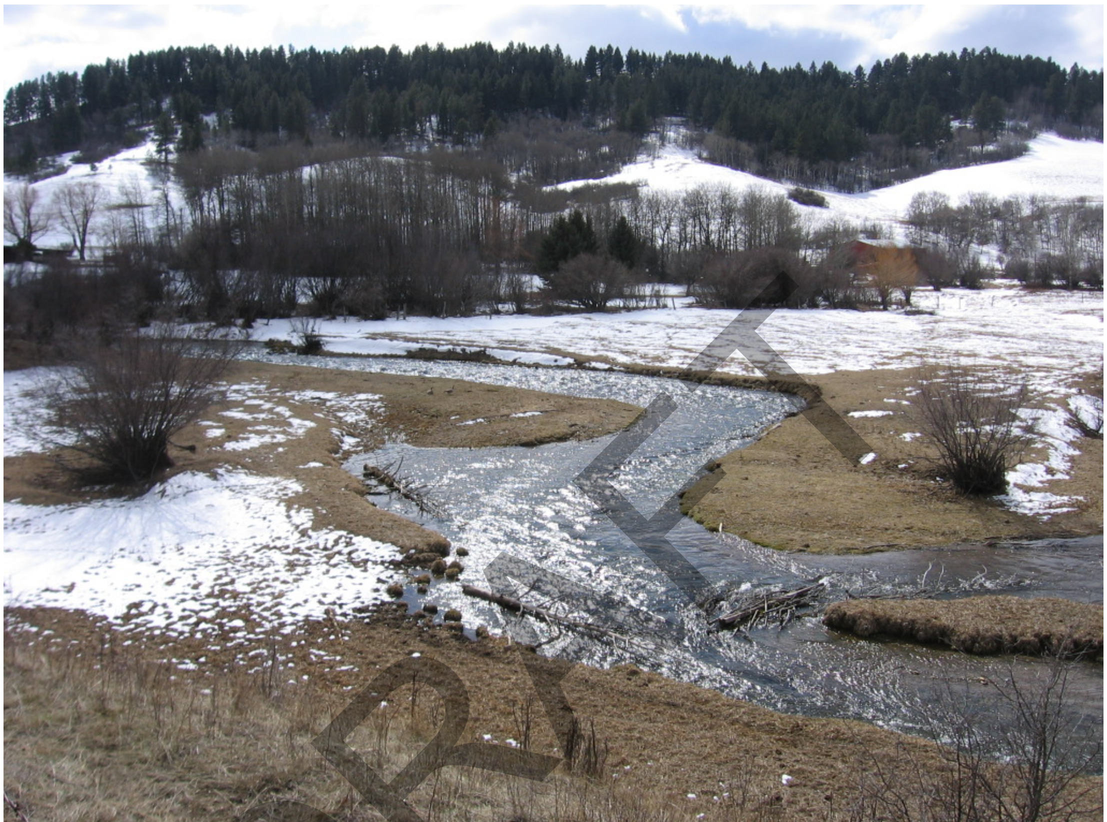
BIG SPRING CREEK
FEASIBILITY STUDY

Fergus County, Montana



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Prepared For:

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FWP Contract No. 7033102

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Olympus Work Order No. A1535

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TABLE OF CONTENTS

DRAFT

DRAFT

DRAFT

LIST OF FIGURES

LIST OF TABLES

DRAFT

LIST OF APPENDICES

DRAFT

1.0 Introduction

Olympus Technical Services, Inc. (Olympus) has prepared this Feasibility Study (FS) for Montana Fish Wildlife & Parks (FWP) under FWP Contract No. 7033102. The FS has been prepared as part of the Remedial Investigation/Feasibility Study (RI/FS) of polychlorinated biphenyls (PCBs) in Big Spring Creek. The procedures for conducting the FS were outlined in a Feasibility Study Work Plan (FSWP - Olympus, 2008a), which was approved by the U.S. Environmental Protection Agency (EPA) in January 2009. The FS provides background information on the site; identification and screening of treatment technologies, general response actions, and process options; development and screening of remediation alternatives; a detailed analysis of remediation alternatives; and a comparative analysis of alternatives.

The FS has been prepared in conjunction with a Remedial Investigation (RI - Olympus, 2009). Data and analyses from the RI have been used to support the preparation of the FS. Additionally, an Initial Alternatives Screening Document (IASD – Olympus, 2009b) was prepared and submitted to both FWP and the EPA for review and approval.

The screening of remediation alternatives is a multi-step process in which treatment technologies, general response actions, process options, and remediation alternatives are evaluated and either retained or eliminated based on a set of evaluation criteria. Each subsequent step in the screening process provides a more rigorous evaluation of options that are retained. For the Big Spring Creek PCB project area, the first level of screening was completed in the FSWP (Olympus, 2008a) by the following steps:

- A large number of treatment technologies were initially evaluated to eliminate technologies that are not fully developed or that have not been proven to be potentially effective for treatment of PCBs.

- Treatment technologies that were retained after initial screening were grouped into various categories of general response actions, technologies, and process options and were then evaluated based on the criteria of implementability, effectiveness, and cost.

The screening was continued in the IASD with the following two evaluation steps:

- The general response actions, technologies, and process options that were retained after initial screening in the FSWP (Olympus, 2008a) were subject to additional, more rigorous screening in the IASD.

- Process options that were retained were grouped into remediation alternatives.

The screening continues in this FS with the following steps:

- Remediation alternatives are subject to a detailed analysis according to criteria established by EPA.

- Remediation alternatives that are retained after the detailed evaluation are compared, and a preferred remediation alternative is selected.

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1.1 Purpose and Organization of the FS

The scope of work for the Big Spring Creek PCB Remedial Investigation/Feasibility Study (RI/FS) consists of the following six tasks per the project scope of work and contract:

1. Remedial Investigation Work Plan
2. Remedial Investigation
3. Remedial Investigation Data Evaluation and Report
4. Feasibility Study Work Plan
5. Feasibility Study Evaluation and Report
6. Community Relations

This FS report represents the results of Task 5. The scope of work for the FS is to produce a FS report which will include, at a minimum, the following components:

1. Introduction.

2. Purpose and organization of the report.

3. Background information (summarized from ERA, HHRA and RI reports), including site description, site history, nature and extent of contamination, contaminant fate and transport, and risk assessment conclusions.

4. A presentation and discussion of results of treatability studies including an assessment of the success of the test(s) and an evaluation of the results as they pertain to the selection of the remedy.

5. A presentation and evaluation of the results of any investigations conducted in addition to treatability study investigations pursuant to the FS Work Plan.

6. A summary of any deviations from the FS Work Plan.

7. All validated field and laboratory analytical results for samples collected during any Treatability Studies and during the FS, as well as for samples collected during the RI which are discussed in the FS, all of which may be separately presented in an appendix.

8. Identification and screening of alternatives

    a. Remedial Action Objectives (RAOs). Present the development of RAOs for each medium of concern (water, fish, sediment, etc.). For each medium, discuss ARARs and any remedial goals.

    b. General Response Actions. For each medium, estimate the areas or volumes to which treatment, containment or exposure technologies may be applied.

    c. Identification and screening of technology types and process options. For each medium, identify and screen potential technologies; evaluate to select a representative process for each technology.

9. Presentation and discussion of results of the detailed alternatives analysis.

    a. Development and screening of alternatives

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i. Effectiveness.
ii. Implementability.
iii. Cost.

b. Detailed analysis of alternatives.

i. Overall protection of human health and the environment.
ii. Compliance with ARARs.
iii. Long-term effectiveness and permanence.
iv. Reduction of toxicity, mobility or volume.
v. Short-term effectiveness.
vi. Implementability.
vii. Cost.
viii. Agency Acceptance.
ix. Community Acceptance.

10. Other pertinent information obtained during the FS.

In addition, the FS report will provide a comparative analysis of alternatives that are retained after the detailed analysis and will present a preferred remediation alternative.

1.2 Background Information

Big Spring Creek, near Lewistown, Montana, is impacted with polychlorinated biphenyls (PCBs), apparently mainly as a result of erosion of PCB-laden paint chips from the upper and lower stations of FWP's Big Springs fish hatchery. PCB-laden paint chips have been found in sediments at least as far downstream as the confluence with the East Fork. The Site is located in Fergus County, Montana, within Section 5, Township 14 North, Range 19 East and Sections 31 and 32, Township 15 North, Range 19 East, Montana Principal Meridian, as shown on Figure 1. The Site encompasses the streambed of Big Spring Creek from the Upper Big Spring Hatchery to the confluence with the East Fork of Big Spring Creek (East Fork), a distance of approximately 2.5 miles. The Site is further subdivided into Reaches 2, 3 and 4 that were previously defined in the risk assessment completed for FWP (CDM, 2005). The reach boundaries are shown on Figure 2 and are defined as follows:

- Reach 2 – Upper hatchery from (including) effluent discharge point downstream to just above lower hatchery effluent discharge point (approximately 0.7 miles)

- Reach 3 – Lower hatchery from (including) effluent discharge downstream to the Cowen Bridge approximately 0.9 miles)

- Reach 4 – Cowen Bridge downstream to confluence with East Fork Creek (approximately 0.9 miles)

Two additional reaches (5 and 6) of Big Spring Creek, located downstream of the Site, were considered in the risk assessment, but were not considered in the RI. These reaches are defined as follows:

- Reach 5 - East Fork confluence with Big Spring Creek to the confluence with Big Casino Creek (approximately 5.1 miles), and

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- Reach 6 - Big Casino Creek downstream to the confluence with the Judith River (approximately 24.1 miles).

1.2.1 Site Description

1.2.1.1 Climate

Climate information was summarized from a Montana Bureau of Mines and Geology (MBMG) Bulletin on the geology and ground water resources of the eastern part of Judith Basin, Montana (Feltis, 1973). While Lewistown is located about 150 miles east of the Continental Divide, it lies north and west of mountains large enough to influence local weather far more than the main chain of the Northern Rockies. Prevailing winds are from the west, and much of the time the air borne on these winds has traveled over the Continental Divide from the Pacific Ocean source regions. Instead of being downslope in the Lewistown area, these winds become upslope because of the mountains in the easterly quadrant. The climate of Lewistown can be described as modified continental in character, with the mountains helping to separate the area from the more representative continental climate zones to the north and east.

Precipitation and temperature data for the period of record at the Lewistown FAA AP (Station 244985) for the period of record 1/8/1896 to 12/31/2007 were obtained from the Western Regional Climate Center (WRCC). A summary of the precipitation and temperature data from this station are presented in Appendix A.

Precipitation at Lewistown is greater than at most locations east of the Continental Divide in Montana, and nearly half falls during the three main growing months of May, June, and July. The annual precipitation for the period of record has ranged from 11.15 inches in 1956 to 28.11 inches in 1978, with an average annual precipitation of 17.65 inches (WRCC, 2008). Average annual snowfall is 62.8 inches per year and the highest measured snowfall was 122.1 inches in 1982 (WRCC, 2008). The temperature in the area is marked by extremes above 100 degrees Fahrenheit (˚F) and below -40˚F. Summer temperatures that reach readings of 90˚F or more occur on an average of 12.4 days in a year (WRCC, 2008). During the winter, severe cold seldom lasts more than a few days without warm “chinook” winds from the west. Minimum temperatures of zero or colder occur on an average of 26.5 days a year (WRCC, 2008).

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1.2.1.2 Location and Topography

The Site is located on the north flank of the Big Snowy Mountains at elevations ranging from approximately 4,080 to 4,200 feet above mean sea level. The Site mostly lies in relatively flat terrain along the banks of Big Spring Creek. Dissected uplands occur on the eastern portion of the Site where several springs and ephemeral drainages are located.

1.2.1.3 Surface Water Hydrology

Big Spring Creek originates from a first magnitude spring (average discharge >100 cfs) at Big Springs, near the upper hatchery. Originating about six miles south of Lewistown above the mouth of Castle Creek and below Hansen Creek Dam, Big Springs discharges at a relatively constant rate year round. Feltis (1973) noted that, “discharge from the spring has gradually increased from about 109 cubic feet per second (cfs) in February 1967 to 132 cfs in January 1969. This increase probably reflects the above-average precipitation during 1967 and 1968 following below-average precipitation in 1966."

A USGS gauging station (06111500) was in operation on Big Spring Creek near the lower hatchery. The coordinates of the gauging station are Latitude 47°00'20", Longitude 109°21'00" (NAD27). The station was operated from June 1, 1932 through September 30, 1957, and the USGS published both daily mean stream flow and annual peak flow data. Discharge readings were also taken at the station sporadically from 1967 through 1971, and again for a portion of 1988 by the Montana Department of Environmental Quality (DEQ); however, these data are unpublished (DEQ, 2005). The daily mean streamflow and annual peak flow data are shown on Figure 3.

The average discharge in Big Spring Creek at USGS gauging station 06111500 for water years 1932-1957 is 107 cfs. The highest recorded flow at station 06111500 was 250 cfs on June 14,1967 (DEQ, 2005). Additional high flows of over 220 cfs occurred in the spring of 1951 and 1953 (Figure 3). These flows reflect substantial short-lived increases resulting from runoff inputs from Hansen and Castle Creek rather than increases in spring discharge.

Before the construction of four flood-control reservoirs upstream from Lewistown, Big Spring Creek saw substantial spring runoff inputs from tributaries: Hansen Creek, Castle Creek, East Fork Big Spring Creek, Pike Creek, and Casino Creek. Hansen Creek reservoir is the only one located within the project area. Unpublished USGS flow data reports flows of 1,200 cfs for Big Spring Creek above Casino Creek and 1,230 cfs at Highway 87 bridge on 5/29/1953 and 5/8/1975, respectively. Spring flooding through Lewistown was not uncommon and eventually resulted in the construction of Hansen Creek, Pike Creek, East Fork, and Casino Creek reservoirs in the early to mid 1970s (DEQ, 2005). Since their construction, flooding has become a rare occurrence. More recent high flows are the result of short events associated with rapid snowmelt or precipitation rather than the seasonal snowmelt and runoff period.

1.2.1.4 Geology

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The geology and ground water resources in the region have been described by Feltis (1973). The area is characterized by folded and faulted sedimentary rocks of Paleozoic and Mesozoic age. The structures are related to the Big Snowy anticline with the formations at the Site generally dipping towards the northwest. Superimposed over this larger structure is a series of smaller domes in this area. The Jurassic age Swift Formation of the Ellis Group forms the local bedrock at the Site. The Swift Formation is composed of fine- to coarse-grained brown to orange glauconitic sandstone containing interbedded shale and conglomeratic sandstone. The formation grades into the varicolored silty shale of the overlying Morrison Formation and is underlain by gray sandy shale and limestone of the Rierdon Formation. The Swift sandstone outcrops in the dissected uplands on the northeast side of the Site. It is overlain by a veneer of alluvial sediments in the floodplain of Big Spring Creek.

1.2.1.5 Hydrogeology

Information regarding site hydrogeology was obtained from Feltis (1973). The primary hydrogeologic feature is Big Springs, which is a discharge point for ground water from the Big Snowy Mountains and the southern part of the Judith Mountains. The spring is attributed to the damming effect of a fault system that displaces the water-bearing Madison Group and Kibbey Formation of the Ellis Group against the more impervious shales in the lower part of the Kootenai. The faults act as conduits for the water to move vertically from these water bearing formations to its discharge point in the Swift Formation. The Big Springs are located in the folded and faulted area of the Heath Dome where water in the deepest aquifer, which has the greatest hydrostatic head, has found its way to the surface.

Montana Bureau of Mines and Geology (MBMG) Ground-Water Information Center (GWIC) records (MBMG, 2006) were reviewed for registered water supply wells located within Section 5, Township 14 North, Range 19 East and Sections 31 and 32, Township 15 North, Range 19 East, Montana Principal Meridian. Well locations, as provided by the MBMG, are shown on Figure 4 and well completion information is summarized in Table 1. The well locations provided by MBMG are often incomplete and inaccurate and several locations shown on Figure 4 are believed to be incorrect. Well records from the MBMG are provided in Appendix B.

1.2.1.6 Historic or Archaeologically Significant Features

A cultural resource inventory (Ethnoscience, 1998) was completed in 1998 in preparation for upgrades to the Big Spring Hatchery. The study identified no cultural resource-related impediments to the renovation activities. The archaeological survey identified no prehistoric sites and evaluation of the hatchery determined that it does not retain sufficient integrity to be recommended as eligible to the National Register of Historic Places.

1.2.1.7 Land Use and Population

Surrounding land is used for agricultural and residential purposes. Most residences are located along Big Spring Creek, although residential development is occurring on the hill slope southwest of the Site. Recreational land use near the Site includes hunting, fishing, camping, hiking, 4-wheeling, mountain biking, snowmobiling, and skiing.

1.2.2 Site History

The following history of PCB source assessments was summarized from DEQ (2005). PCBs were first detected in fish tissue from feral fish collected below Lewistown in 1981. Since initial detection of PCBs in fish tissue, considerable investigation to ascertain the source and distribution of PCBs in the Big Spring Creek watershed has been conducted by a variety of individuals and agencies: DEQ, FWP, Fergus County Conservation District, MBMG, EPA, private citizens, and school groups. Efforts conducted in 2003 to locate the source of PCB led investigators upstream to the Big Springs Trout Hatchery where marine paints, applied to hatchery raceways in the 1960s and 1970s, are thought to be the source of PCB contamination in Big Spring Creek. The following synopsis of activity from 1981 through 2003 describes data collection and assessments conducted by multiple efforts (DEQ, 2005).

In 1981, fish tissue sampling in Big Spring Creek downstream of Lewistown detected PCBs in rainbow trout. Two trout were sampled yielding PCB levels of 0.08 and 0.07 ppm. These levels were well below the U.S. Food and Drug Administration (FDA) recommended action level of 3.0 ppm. Fish tissue sampling was conducted again in 1986 (near Mill Ditch), 1992 (below

DRAFT

Lewistown) and 1998 (Brewery Flats). The PCB mixture, Aroclor 1254, was detected in all fish sampled.

Levels of PCBs found in fish tissue prompted several efforts to identify the source of the PCBs. In October of 1996, FWP sampled sediments in Big Spring Creek at three locations: Burleigh Fishing Access Site (FAS), Brewery Flats, and near Highway 200. PCBs were detected at each location. In 1997, Isaac Opper, a concerned local youth aided by the MBMG, sampled stream sediment at 13 sites along a 10-mile length of Big Spring Creek centered around the Brewery Flats area. Brewery Flats is upstream from Lewistown and was used as an industrial site for nearly one hundred years. Historically, Brewery Flats served as a rail yard, feedlot, brewery, oil refinery, and loading station for nearby coalmines. Results of Isaac's sampling showed four of the 13 sites had positive PCB (Aroclor, 1254) detections ranging from 0.0193 to 0.052 ppm. The positive PCB results came from a stretch of Big Spring Creek between the southern boundaries of the Brewery Flats FAS to just upstream of Lewistown.

Based on the positive sediment sample results, DEQ led four sampling events in early 1998 (January, March, April, and May), aimed at collection of stream substrate samples in the Brewery Flats area. The upstream boundary of the sampling was the southern boundary of the Brewery Flats FAS. The sampled reach covered approximately 2,900 feet of stream channel. Thirty-five samples were collected over the four field visits. All had detectable PCB (Aroclor, 1254) ranging from 0.0025 to 0.221 ppm. During the same sample period, DEQ attempted to relate PCB detection in sediment samples to soil and groundwater in the Brewery Flats area. All soil and groundwater samples were below detection limits for PCBs.

In May and June of 2000, a Site Inspection and a Brownfields Assessment Report were completed by the EPA. The objective of these studies was to characterize contaminants (volatile organic compounds, semi-volatile organic compounds, PCBs, diesel range organics, and metals) in order to determine suitability of the Brewery Flats site for recreational development. The site inspection was centered at the old Milwaukee Road Railroad roundhouse on Brewery Flats. Sixty-one waste source, soil, groundwater, surface water, and sediment samples were collected. No PCBs of the Aroclor 1254 type were detected in any samples.

The Brownfields Assessment sampled soil, subsurface soil, groundwater, surface water, and stream sediment for volatile organic compounds, semi-volatile organic compounds, PCBs, diesel range organics, and metals at a variety of locations on Brewery Flats. PCBs were detected in surface soil samples yet were of a different PCB mixture (Aroclor, 1260) than those found in fish tissue and stream sediment. PCBs were not detected in any of the surface water, sediment, groundwater, or subsurface soil samples.

With 319 funding through the Fergus County Conservation District, the Montana DEQ again sampled Big Spring Creek sediments in April 2003. Having failed to find the source of PCB at Brewery Flats in past sampling events, efforts focused on locations upstream from Brewery Flats. Samples were collected along Brewery Flats, in a recently restored channel in Brewery Flats, and at several sites upstream from Brewery Flats to just above the confluence with East Fork Big Spring Creek. Values were erratic and ranged from below detection limits to 1.9 ppm, the highest PCB concentration detected up to that time. All samples collected from the newly constructed stream channel in the Brewery Flats Restoration Project were below detection limits, suggesting that accumulation of PCB in the new stream channel over the previous three years (from the time of channel construction to the time of sampling) was negligible.

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Following the April 2003 results, sediment sampling resumed in June of 2003, starting at the site upstream of the Big Spring Creek's confluence with the East Fork and continuing upstream. Six sites were sampled along the mainstem of Big Spring Creek from the confluence of the East Fork to just above the Big Springs Trout Hatchery. Positive detection for Aroclor 1254 was found in all six mainstem sites with values ranging from 0.074 to 5.9 ppm. In addition, two small tributary streams, Hansen and Castle Creeks, were sampled at their mouths. Hansen Creek and Castle Creek enter Big Spring Creek above and just below the Big Springs Trout Hatchery, respectively. Both samples were below detection limits for PCBs suggesting the source of the PCB (Aroclor, 1254) is in the general area of the Big Springs Trout Hatchery and not from sources upstream from the hatchery.

Prompted by the levels of PCB detected in stream sediments, FWP investigated the hatchery facilities to determine whether PCBs found in fish tissue and sediments might be originating from sources at the facility. Samples of hatchery raceway paints tested positive for PCBs (Aroclor, 1254).

FWP contacted the EPA requesting guidance on what appropriate action was required. Acting under EPA guidance, FWP initiated a site characterization of the hatchery raceways to determine the magnitude and extent of raceway contamination by paint containing PCBs. Results of this characterization indicate that three different paints were used to line the hatchery raceways. A blue-green colored "swimming pool" paint was applied in the early 1960s and in some raceways it was covered with two different red paints (red #2 and red #3). Analysis of the blue-green paint yielded PCB concentrations of 86,500 ppm. The red #2 paint was applied in the years before 1980 and was comprised of 674 ppm PCB. The third variety of paint, red paint #3, was applied after 1980 and yielded a PCB concentration of <0.15 ppm.

FWP commissioned human health and ecological risk assessments that were completed by Camp, Dresser, and McKee (CDM). FWP sampled stream sediment, soil, surface water, ground water, fish, aquatic plants (algae), and benthic macroinvertebrates in 2003 and 2004 to support the risk assessments. The risk assessments were completed in 2005 and addendum was completed in 2008. The risk assessment results are summarized in Section 1.2.5.

In 2005, four Lewistown attorneys commissioned a RI and FS of the Big Spring Creek site in preparation for litigation of a class action lawsuit on behalf of the owners of land adjoining Big Spring Creek. The RI was completed in 2006 by Herrera Environmental Consultants (Herrera). The FS was completed by Herrera in May 2006.

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1.2.2.1 Hatchery Development History

Information regarding development of the hatchery was obtained from a cultural resource inventory completed for the hatchery (Ethnoscience, 1998) and from interviews with Jack Boyce, the former hatchery manager. The development of both the upper and lower stations is described below.

1.2.2.1.1 Upper Station

The upper station of the hatchery consists of a combination of buildings and structures that include two hatchery buildings, two residences, a firehouse, a bunker over Middle Big Spring, outdoor concrete raceways, a show pond, a rock-walled spring area, a cap over Big Spring and an overflow pond. Landscaping within the property includes lawns, hedges, and mature willow trees. The upper station is bounded to the west by Highway 466, to the east by a rugged hillside, and to the north and south by open scrub areas.

A portion of the old hatchery building was first constructed in 1924. This building is used as a garage, storage area, and an initial rearing area for hatchery fish. The building was modified into a garage in 1933, the hatchery room was added on in 1939 and other modifications occurred in 1940, 1948, 1953, 1979, 1989, 1992, and 1997. The building currently measures 37 feet by 116 feet and it is constructed on a concrete pad.

The main hatchery building was constructed around 18 pre-existing concrete raceways in 1948 and the building was further modified in 1988, 1989, 1991, 1992, and 1996. In addition to the raceways, the building contains office, shop, and storage areas.

Residence 1 was constructed in 1940. This residence is a one-story, wood frame building with a full concrete basement. Residence 2 was constructed in 1973. It is a modular building with a full concrete basement.

The firehouse was built sometime during the 1960s or 1970s and houses the fire pump and hose. This small, wood frame building measures 12 feet by 12 feet and sits on a concrete pad on the northwest side of the old hatchery building.

A concrete bunker was built over the Middle Big Spring (Upper Spring #2) in the 1930's or 1940's. The bunker measures 25 feet by 50 feet.

The outdoor raceways were constructed in 1987. They include eight concrete raceways that cover an area of 60 feet by 60 feet.

The show pond is a circular concrete pond constructed in 1987 that measures 16 feet in diameter. The show pond, located directly north of the outdoor raceways, contains trout from the hatchery.

The rock-walled spring area was constructed between 1933 and 1937. The rock-walled spring area includes an island with several bridges. A concrete aquarium was historically located in this area but was demolished in the 1980's.

The Big Spring cap was constructed over the main spring between 1930 and 1939. The City of Lewistown maintains this cap and draws water from beneath it as a water source for the city. The cap measures 60 feet in diameter and was modified in 1996-1997.

1.2.2.1.2 Lower Hatchery Station

The lower station of the hatchery includes a series of outdoor concrete raceways, a building used for office and shop space, and an underground water pipeline. Construction of the lower hatchery, including both the raceways and shop/office building, was initiated in 1959 or 1960.

The lower raceways consist of seventeen 111-foot long raceways, thirteen 71-foot long raceways, and one 244-foot long canal raceway. Each raceway is approximately 7.5 feet wide and the walls are approximately 3.5 feet high. The raceway surfaces are concrete, although some steel is present in the form of channel iron through which the gates are placed. The lower

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shop is a framed structure that includes a small office, restrooms, and a shop area divided into several rooms with a small loft. The building rests upon a concrete slab that is approximately 50 feet by 80 feet in size.

Residences #3 and #4, constructed in 1960, are wood frame buildings with a partial concrete floor. A separate garage was constructed to the north of residence #4 in 2000.

FWP discovered the presence of PCBs in paint in the lower hatchery raceways in August 2003 when a paint sample collected from a raceway surface was found to contain 1,150 milligrams per kilogram (mg/kg) PCB (Aroclor 1254). This initial paint sample was collected from a short raceway where both blue-green and red paint had been applied.

Additional paint samples were collected from the lower raceways by FWP in December 2003 and the results indicated that there had been at least three types of paint used at the hatchery site. A blue-green paint was used throughout the canal raceway and short raceways and on the south wall and the southernmost 11 to 13 feet of floor in the long raceways. A sample of the blue-green paint collected from the canal raceway contained 86,500 mg/kg PCB. A red paint purchased prior to 1980 was used on all of the raceways except for the portion of the canal raceway upstream of the short raceways and a sample of it contained 674 mg/kg PCB. A sample of red paint purchased after 1980 did not contain PCBs above the method detection limit (<0.15 mg/kg).

1.2.2.2 2005 Lower Hatchery PCB Removal and Encapsulation Project

A PCB removal and encapsulation project was completed by FWP at the lower station of the hatchery in 2005. The work consisted of the following:

- removal of paint containing PCBs and/or lead from the lower raceways;
- disposal of the paint and blasting waste at a licensed TSCA PCB disposal facility;
- installation of screens to create quiescent zones in the raceways;
- coating of the raceways with a poly urea coating to encapsulate PCBs that remain in the concrete;
- conversion of the lower canal into a two-cell settling basin; and
- removal and disposal of paint-impacted soil around the raceways and replacement with clean backfill.

Several removal actions were added to the project once it started. They included the:

- disposal of selected painted materials and debris that had been located at the upper and lower hatcheries;
- removal and disposal of a painted deck and boards used for a raised asparagus bed at Residence #2 near the upper hatchery;
- removal and disposal of impacted soil from the deck and asparagus garden at Residence #2;
- removal and disposal of painted wood and paint chips from Upper Spring #2, which is located southeast of the main hatchery building at the upper hatchery;
- removal and disposal of painted debris, including cans, concrete, wood, and tanks from a historical dump above the upper hatchery;

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- removal and disposal of PCB-impacted soil from a burn pit and debris pile near the historical dump above the upper hatchery; and
- removal and disposal of PCB-impacted soil located on the southeast side of the main hatchery building at the upper hatchery.

1.2.2.3 2005 Hatchery Site Characterization

FWP completed a site investigation in 2005 designed to evaluate the extent of PCB impacts to painted surfaces, soil, and water at the Big Springs Trout Hatchery. The investigation was conducted by Olympus under contract with FWP. The field sampling program included the following components:

- The collection of 16 paint samples for PCB analysis, 12 paint samples for total lead analysis, and 4 paint samples for TCLP metals analysis.
- The collection of 107 soil samples for PCB analysis and 39 soil samples for lead analysis as part of the original sampling and analytical plan.
- The collection of 3 concrete samples for PCB analysis and one concrete sample for lead analysis.
- The collection of 3 wipe samples for PCB analysis.
- The collection of 6 ground and surface water samples for PCB analysis and 1 surface water sample for lead analysis.

The results of the investigation can be best described based on the media investigated, i.e. paint, soil, and water. Paint sample collection was conducted in areas where PCBs were suspected to be present in the paint. PCBs were detected in paint samples collected from the:

- exterior surfaces of the old raceways inside the main hatchery building;
- concrete walls inside the main hatchery building;
- wood walls inside the main hatchery building;
- office and chiller room floors inside the main hatchery building;
- concrete walls on the exterior of the main hatchery building;
- rim of a painted fiberglass sink in the main hatchery building;
- hatchery and storage room floors in the old hatchery building;
- fiberglass troughs in the hatchery room of the old hatchery building;
- basement walls and floor of Residence #1;
- basement floor and porch of Residence #3; and,
- office and restroom floors of the lower hatchery shop.

All of the paint samples collected during this investigation contained PCBs at concentrations above the PCB in paint action level of 0.5 mg/kg. There is also a regulatory threshold for disposal of PCB products of 50 parts per million (ppm) or mg/kg (Title 40 CFR Part 761.3). Paint with a PCB concentration of less than 50 mg/kg is not regulated for use or disposal purposes beyond the disposal regulations that typically apply to non-hazardous waste. PCB concentrations above 50 mg/kg were detected in paint samples collected from the:

- exterior surfaces of the old raceways in the main hatchery building;
- concrete walls in the interior of the main hatchery building;
- office floors in the main hatchery building;
- storage room floors in the old hatchery building; and,
- basement walls and floor of Residence #1.

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While the paint in many areas does not contain PCB concentrations above the regulatory threshold level, the hatchery site is a sensitive area with continuous residential and operations occupancy as well as proximity to Big Spring Creek. It was recommended that all of the surfaces coated with PCB-containing paint be addressed to reduce human health and environmental exposure to the PCBs. FWP is preparing a separate workplan addressing remediation of PCBs outside of the streambed at the hatchery.

Potential impacts to ground water and hatchery discharge water were evaluated during this investigation through the collection of six natural water samples and one field duplicate water sample. Areas sampled include Upper Springs #1 and #2, the water system for Residences #1 and #2, water discharging from the old raceways in the main hatchery building, and ground water in the vicinity of the historical outside raceways located adjacent to the main hatchery building. None of the samples contained PCB concentrations above the analytical method detection limit. These data indicate that leaching of PCBs from impacted soil, painted surfaces, and buried concrete to ground water or surface water is not occurring at levels that can be detected. This is expected given the low solubility of PCBs and their presence in paint rather than oil at this Site. No further assessment of ground water was recommended.

1.2.3 Nature and Extent of Contamination

The nature and extent of PCB contamination have been investigated through several efforts which have been summarized in the RI (Olympus, 2009) and by others (DEQ, 2005; CDM, 2005, 2008, and 2009; and Herrera, 2006). These investigations have identified the hatchery raceways as a point source of PCB-laden paint that subsequently entered Big Spring Creek. The paint has been removed from the hatchery raceways and disposed. Paint sources that remain at the hatcheries are primarily located in buildings and other areas that will not be discharged to Big Spring Creek. These areas of the hatchery facilities are also under investigation for remediation. Previous investigations (DEQ, 2005; CDM, 2005 and 2008) have not shown significant PCB impacts to other abiotic media at the Site (i.e., surface water, ground water, soil or air). PCB impacts have been measured in fish and other biota (Olympus, 2009; DEQ, 2005; and CDM, 2005, 2008, and 2009).

The Big Spring Creek streambed has been identified as a non-point source of PCBs (DEQ, 2005). PCBs are distributed sporadically through both the horizontal and vertical profiles of the stream bed in Reaches 2, 3, and 4, and the PCB concentrations are highly variable. The horizontal and vertical extent of PCB impacts have been evaluated through sampling of stream sediment. Two primary data sets have been used to quantify the horizontal and vertical extent of PCBs in stream sediment. PCB data in stream sediment data collected by Herrera (2006) have been used primarily to evaluate the horizontal distribution of PCBs, while the Phase 1 RI data (Olympus, 2009) have been used to supplement the Herrera data and further define the vertical extent of PCBs in stream sediment. The longitudinal profiles of PCB concentrations for the Herrera stream sediment data are summarized on Figure 5 through Figure 8 and the Phase 1 RI data are summarized on Figure 9 through Figure 15.

Both the Herrera and Phase 1 RI stream sediment data sets are highly variable with respect to PCB concentrations. The high degree of variability is largely attributable to sample heterogeneity (i.e., “nugget effect”), as described in the RI (Olympus, 2009). The nugget effect makes it difficult to quantify a representative measurement of central tendency because a small number (as few as one or two) of high PCB concentrations can skew the data and dominate the calculation of an arithmetic mean even if there are a large number of low concentration values.

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Conversely, median PCB concentrations, while representing the center value, neglect the effect of higher concentrations. Because of the “nugget effect” and the quandary related to defining a representative measure of central tendency, a more conservative statistic, the 95% Upper Confidence Limit (UCL) of mean PCB concentrations, was adopted for evaluating exposures.

The media to which general response actions may be applied include in-stream sediment located in Reaches 2, 3, and 4. Site characterization data (Olympus, 2009 and Herrera, 2006) indicate that PCB concentrations exceed the project screening level of 189 µg/kg in each reach in the study area. PCBs were detected in stream sediment at depths up to 36 inches deep and at concentrations exceeding screening level at a depth of up to 24 inches.

The PCB concentrations are generally highest in areas directly below the upper and lower hatcheries, although PCB concentrations exceed the screening level in individual samples collected from other areas downstream from the hatcheries. For the purpose of the RI/FS, the 95% UCL of the mean PCB concentration is used to quantify the PCB concentration and compare to the project screening level. The 95% UCLs of the mean PCB concentration were calculated using EPA’s ProUCL statistical software package (EPA, 2007a and 2007b). The UCLs were calculated using the stream sediment data collected by Herrera (2006). The Herrera data are used for the UCL calculations because it is a larger data set that provides a greater coverage of the horizontal extent of PCB impacts to stream sediment than the Phase 1 stream sediment data (Olympus, 2009). Phase 1 stream sediment data were collected at deeper sample intervals than the Herrera data and are used primarily to further define the vertical extent of PCB impacts to stream sediment. Details of the UCL calculations are presented in the RI report (Olympus, 2009). The 95% UCLs of mean PCB concentrations are presented by depth interval, deposition type, reach, and subreach in Table 2 through Table 5. The mean PCB concentrations by subreach and depth interval are presented in Table 6. The mean PCB concentrations range from approximately 15 to 16,600 µg/kg. By comparison, the mean PCB concentrations are 1.1 to 5.4 times lower than the 95% UCLs for the same sediment units shown in Table 5. This is an indication of the degree of variability in the stream sediment data.

An objective of the RI was to quantify PCB concentrations by geomorphic or habitat types, which would be conducive to small scale or “hot spot” removal of PCBs; however, the high variability of PCB concentrations in the stream sediment data was not suitable for this level of analyses. Therefore, the PCB data were evaluated by calculating 95% UCLs for larger groupings including depth interval; reach, deposition type, and depth interval; reach and depth interval; and subreach and depth interval.

The following general trends have been observed in the PCB data collected from the stream bed:

- PCB concentration in sediments is typically higher in depositional than in transport areas.

- PCB concentration tends to decrease both with depth within the sediment bed, and with distance from the two hatcheries.

- PCB concentrations are highly variable and PCB concentrations exceeding the project screening level and TMDL target concentration 189 µg/kg were observed throughout the Site, including in transport areas, in the farthest downstream reach, and in deeper sample intervals.

DRAFT

The 95% UCL calculations show generally show the following trends:

- The 95% UCL of mean PCB concentrations decrease with increasing sample depth (Table 2).
- The 95% UCL of mean PCB concentrations are generally greater in depositional versus the transport regime (Table 3), but not in all reach and deposition/transport regime combinations.
- The 95% UCL of mean PCB concentrations exceed the project screening level in Reaches 2 and 3 in depth intervals H1, H2, and H3, while UCLs are less than the screening level for all of Reach 4 and all of depth interval H4 (Table 4).
- The 95% UCL of mean PCB concentrations are generally higher in the upstream half of Reaches 2 and 3 (i.e., Subreach 2A and 3A) than in the downstream half of the reaches (Subreach 2B and 3B), but not in all subreach and depth interval combinations (Table 5). This supports Herrera's statistical evaluation that showed that distance from the two hatchery sources is a significant factor. Subreaches 4A and 4B do not necessarily follow this trend. The higher UCL in Subreach 4B is likely because of increased deposition near the confluence with the East Fork.

According to concurrent fish tissue and stream sediment samples collected by FWP between 2003 and 2008 (Olympus, 2009), PCB concentrations in rainbow and brown trout tissue show both spatial and temporal trends. PCB concentrations in fish tissue decrease with downstream distance from the hatcheries for samples collected during the same sampling event. Similarly, PCB concentrations in fish tissue decreased over time at each sample location. These samples also indicated a large reduction in PCB concentrations in fish tissue in samples collected before and after the 2005 cleanup at the lower hatchery raceways. Tissue samples collected from rainbow trout showed decreases in PCB concentrations ranging from 5.25 to 40 times at all sites samples before and after 2005 (below hatchery, Garlic Farm, Brewery Flats, Carroll, and Hruska). Brown trout tissue samples showed a decrease of 2.5 to 26 times during the same period at the same sites. However, PCB concentrations in fish tissue have remained relatively constant between samples collected in September 2006 and September 2008. These data indicate that, while PCB source removal at the lower hatchery had a significant effect on fish tissue concentration, the PCB concentrations in fish tissue are still elevated. Stream sediment samples collected concurrently with the fish tissue samples generally showed trends similar to the fish tissue data, although there was more variability.

The volume of PCB-impacted sediment was estimated for a variety of removal scenarios in the RI (Olympus, 2009). The removal scenarios considered both partial- and total-sediment removal. Table 7 presents the sediment removal volume calculations. Sediment removal volumes ranged from approximately 4,800 cubic yards (CY) to nearly 15,800 CY for the partial removal scenarios. The partial removal scenarios vary both by the areal extent of the removal and by the removal depth to provide volume estimates for conditions ranging from surficial removal from only the highest impact areas (Volume Scenario 2) to removal of sediment from all areas with a 95% UCL of mean PCB concentrations that exceed the TMDL target concentration of 189 µg/kg (Volume Scenario 3).

The depth of PCB impacts varies both within and among reaches and subreaches. Therefore, total removal of PCB impacts is subject to interpretation of what constitutes total removal. PCBs were detected in two samples (30 and 43 µg/kg) from as deep as 30 to 36 inches (Olympus,

DRAFT

2009), although these concentrations are near the analytical detection limit and did not exceed the TMDL target concentration of 189 µg/kg. The fish tissue/sediment relationship shows that PCB concentrations would need to be near zero to allow unlimited consumption of fish. Therefore, a removal depth of 36 inches, which includes all PCBs detected in the Phase 1 and Herrera RI sampling, was selected for total removal (Volume Scenario 4). The total removal volume under this scenario is approximately 71,000 CY.

An additional volume scenario (Volume Scenario 5) has been added to include the partial removal of sediment to a depth of 6 inches over the entire Site area. The sediment volume for this scenario is approximately 11,830 CY.

1.2.4 Contaminant Fate and Transport

The fate and transport of PCBs in Big Spring Creek is largely a function of suspension, deposition, and redeposition of the paint chips (in which the PCBs are apparently bound) that are mixed with stream sediment particles. The suspension and transport of sediment and paint chips is controlled by moving water. Greater volumes of sediments become suspended and are transported during high-flow events (such as storms and spring snowmelt).

A significant factor in the rate of transport of PCBs is the stable and relatively limited flow regime in Big Spring Creek. Big Spring Creek originates from a large spring located near the upper hatchery and has a very consistent base stream flow. Periodic historical flooding in Lewistown prompted the construction of four flood-control reservoirs upstream from Lewistown on tributaries to Big Spring Creek in the early to mid 1970s. Since this time, peak flows have been attenuated by these reservoirs, which has limited both the amount of sediment transport and upstream sediment supply from tributaries to Big Spring Creek. These factors have tended to limit the movement of sediment (and associated paint chips) and limit the dilution of PCB concentrations by introduction of clean upstream sediment. The limited movement of sediment is evidenced, to a certain extent, by the distribution of PCBs in the creek. Although PCBs have been detected at a distance of several miles below the hatcheries, the highest PCB concentrations are generally observed in the area immediately below both hatcheries where the paint chips originated. Even though paint (suspected of containing PCBs) was removed from the interior surfaces of the old raceways inside of the main upper hatchery building in the 1980's (Olympus, 2006), the area directly below the upper hatchery has the highest concentrations (Table 4 and Table 5). This supports the hypothesis that transport and dispersion of PCBs is limited. PCB concentrations generally decrease with distance from the hatcheries.

The fate of PCBs in Big Spring Creek is influenced both by the persistent nature of PCBs and by the form in which the PCBs are present. Environmental persistence indicates whether a chemical is likely to be long-lasting in the environment or, alternatively, be degraded by natural processes. Higher chlorinated PCBs, i.e., those with five or more chlorine atoms, are more persistent in the environment than those with three or less chlorine atoms (ATSDR, 2000). Analytical results show that PCBs in abiotic media and fish sampled at the Big Spring Creek Site have been in the form of Aroclor-1254, which is a higher-chlorinated Aroclor.

PCBs, particularly the highly chlorinated congeners, adsorb strongly to sediment and soil where they tend to persist with half-lives on the order of months to years (ATSDR, 2000). There is no abiotic process known that significantly degrades PCBs in soil and sediment. Photolysis of PCBs from surface soil may occur, and PCBs may also undergo base-catalyzed dechlorination;

DRAFT

however, both of these processes are likely to be insignificant removal mechanisms (ATSDR, 2000).

Although PCBs tend to bind strongly to soil, sediment, and organic particles, , the PCBs found in Big Spring Creek appear to remain bound in paint chips and mix with sediment rather than the PCBs binding to the sediment. As paint chips are transported and redeposited, they are thought to break down into smaller particles. This is evidenced by samples that were collected for particle size analyses during the RI (Olympus, 2009) sediment sampling and the suction dredge pilot study (FWP, 2007). Paint chips were manually removed from each sieved fraction using forceps and were quantified by weight. For the two fractions smaller than 0.85 mm, it was only possible to identify paint chips with the aid of a dissecting microscope. For the smallest size fraction (<0.074 mm), the paint chips could not be removed from the surrounding sediment matrix without picking the sediment as well. Although it has not been tested by experimentation, it is believed that the paint chips in the smaller size fractions are likely to be more bioavailable for uptake by aquatic organisms.

PCBs are taken up into the bodies of small organisms and fish in water. They are also taken up by other animals that eat these aquatic animals as food. PCBs especially accumulate in fish and marine mammals (such as seals and whales) reaching levels that may be many thousands of times higher than in water (ATSDR, 2000). PCB levels are highest in animals high up in the food chain.

Modeling is often used to interpolate or extrapolate contamination based on statistical trends. Because of the high variability of the data (i.e., nugget effect), models are not a reliable option for predicting trends in PCB concentrations in stream sediment. Therefore, the extent of PCB contamination has been defined through the use of discrete stream reaches and/or subreaches at specified depth intervals. The 95% UCLs of mean PCB concentrations have been calculated for these discrete units to evaluate potential exposures rather than through the use of predictive models. The results of the UCL calculations are presented in Section 1.2.3.

1.2.5 Summary of FWP Risk Assessments

An initial step in the planning process to address PCB contamination in Big Spring Creek was the completion of a series of assessments evaluating risks to human and ecological receptors following EPA and DEQ guidelines and requirements (CDM, 2005). Sampling to support development of the baseline ecological risk assessment (BERA) and human health risk assessment (HHRA) included the following:

- benthic sediment,
- soil samples from the Big Spring Creek floodplain and gardens irrigated from Big Spring Creek,
- groundwater from domestic wells,
- surface water,
- fish tissues (whole fish and fillets),
- benthic macroinvertebrates, and
- paint chips.

DRAFT

1.2.5.1 Human Health Risk Assessment

The objective of the HHRA was to determine whether PCB contamination in Big Spring Creek presents a significant current or future threat to humans living in proximity to Big Spring Creek, or recreating on or near the Site. Evaluation of PCB concentrations in media from the Site, assumptions on potential exposure of residents and recreationists, and literature review of toxicity of PCBs provided the basis for developing the HHRA.

Potential avenues for exposure to PCBs evaluated in the risk assessment included recreational exposure to contaminated sediment and surface water, ingestion of PCBs from contaminated garden vegetables, ingestion of PCBs from domestic wells, incidental ingestion of contaminated soils, and consumption of contaminated fish. Of these potential routes, consumption of contaminated fish tissue emerged as the only significant source of exposure for humans.

A significant body of science allows inference on the effects of PCB exposure on human health (ATSDR, 2000). Using this information, the EPA established toxicity criteria for both cancer and non-cancer effects of PCB exposure. The HHRA used these criteria, along with exposure estimates, to calculate potential risks and hazards to human health.

Calculated risks associated with consumption of fish caught in Big Spring Creek were high and often exceeded the EPA's acceptable risk range of 1 in 1,000,000 (10^{-6}) to 1 in 10,000 (10^{-4}). The cancer hazard risk for Area 3 exceeded the maximum acceptable cancer risk by 2000% (Figure 16). This means that ingestion of fish by sport anglers results in a cancer risk of about 2×10^{-3} or 2 excess cancers attributable to PCB exposure in every 1,000 exposed individuals. Risks associated with brown trout were higher than for rainbow trout, which may reflect trophic relations. Brown trout are more likely to be piscivorous than rainbow trout, and therefore, have a greater potential to accumulate PCBs given their higher trophic status. Nonetheless, risks associated with consuming trout from Big Spring Creek exceed EPA's acceptable range at all sampled reaches within the Site for both species.

Cancer is not the only health hazard associated with exposure to PCBs. Calculation of the non-cancer hazard involved dividing exposure estimates by toxicity criteria that represent the highest "safe" exposure level to yield a hazard quotient. Hazard quotients associated with consumption of fish captured on Big Spring Creek exceeded the hazard quotient considerably (Figure 17), with the highest hazard quotient calculated for Area 3, which is located downstream of both hatchery units. The hazard quotient is a unitless ratio of a receptor's exposure level (or dose) to the "acceptable" (or allowable) exposure level. A hazard quotient of 1 or less indicates that the receptor's exposure is equal to or less than an "allowable" exposure level, and adverse health effects are unlikely to occur. A hazard quotient greater than 1 indicates a possibility for adverse health effects.

In summary, the major findings of the HHRA (CDM, 2005) are:

- Eating fish taken from the creek, particularly in the reaches just below the hatchery is the primary pathway for ways that humans might be exposed to PCBs from Big Spring Creek. Under the assumptions for the sport angler, the excess cancer risk may be 16 times higher than EPA's "acceptable range." For non-cancer effects, the consumption of fish by the sport angler results in a level of exposure to PCBs that could be as great as 96 times higher than EPA's reference level of one. It is important to note that risks are conservative in the sense that they assume the angler consumes 24 meals per year for 30 years. The high risks therefore shown for Reach 3 assume the angler consumes fish

DRAFT

exclusively from this reach of the stream for 30 years. Risks would be lower if the angler consumed fish from the other areas, from non-contaminated waterbodies, or at lower rates of consumption.

- Risks from being exposed to PCBs in Big Spring Creek through incidental ingestion and dermal contact with contaminated sediments and creek water are significantly below EPA's levels of concern for cancer and non-cancer health effects based on a recreational scenario.

1.2.5.2 Baseline Ecological Risk Assessment

The BERA evaluated risks to ecological receptors likely to be exposed to PCBs in the Big Spring Creek watershed (CDM, 2005). Specific components of a BERA include the following:

- Identification of chemicals of concern,
- Determination of appropriate ecological receptors,
- Estimation of the possible exposure of these receptors to chemicals of concern,
- Determination of extent of exposure that could cause adverse effects,
- Characterization of potential threats to ecological receptors, and
- Discussion of relevant uncertainties in results of the risk assessment.

Ecological receptors considered in development of the BERA included terrestrial and aquatic taxa of plants and animals grouped by trophic level or habitat association. These included the following:

- Aquatic and semi-aquatic invertebrates (primarily aquatic insects and crustaceans),
- Commonly consumed salmonid fishes (rainbow and brown trout),
- Forage fishes,
- Terrestrial-linked carnivorous birds,
- Piscivorous birds,
- Insectivorous birds,
- Terrestrial plants,
- Terrestrial soil-dwelling invertebrates (e.g. earthworms)
- Small burrowing omnivorous terrestrial mammals, and
- Piscivorous mammals (e.g. mink).

The exposure assessment component of the BERA summarized contaminant sources and described how ecological receptors can be exposed to Site-related contaminants. The exposure assessment yielded a site conceptual exposure model that related sources of contaminants, in this case paint chips, transport mechanisms (discharge from the hatchery and subsequent transport with stream flow), exposure routes, and receptors.

The second outcome of the exposure assessment was estimation of exposure point concentrations, which are concentrations of chemicals that the ecological receptor might contact. Area specific exposure point concentrations allow evaluation of ecological risks across assessed sites.

Results of the BERA identified elevated hazard quotients for aquatic organisms and terrestrial organisms that consume aquatic organisms. These are similar to hazard quotients calculated

DRAFT

for the HHRA and are ratios of measured or modeled concentrations or doses to effects concentrations from the literature. Mink bore the highest risk due to their exposure to contaminated fish and benthic sediments. Food web and sediment exposures resulted in elevated risks to piscivorous birds and those consuming aerial adults of insects with an aquatic larval stage. Benthic macroinvertebrates had the next greatest risk due to their direct exposure to contaminated sediments. The presence of PCBs in tissues gave trout the next ranking, with respect to hazard quotient, with exposure being through consumption of macroinvertebrates and incidental ingestion of contaminated sediment.

The BERA analyses (CDM, 2005) comparing measured concentrations and the effects concentrations produced the following conclusions:

- Risks to mink based on estimated sediment/fish relationships for PCBs appear elevated (Reaches 2-4).
- Risks resulting from food web modeling and PCB exposures in sediment are elevated for mink, marsh wren, great blue heron, and belted kingfisher.
- Risks to benthic macroinvertebrates via direct exposure to PCBs in sediment are elevated (Reaches 2-6).
- Risks to soil microbes or soil microbial functions due to PCBs in soil/floodplain sediment are insignificant or only slightly elevated (Reaches 4 and 5).
- Risks from exposure to PCBs in surface water are insignificant.
- Risks to rainbow and brown trout from PCBs in tissue are insignificant based on measured or estimated (from fillet) whole body PCB concentrations in forage fish.
- Risks to benthic macroinvertebrates via direct exposure to copper in sediment are insignificant.
- Risk to most soil-dwelling receptors are insignificant based on PCB concentrations in soil/floodplain sediment.
- Risks resulting from food web modeling and PCB exposures in soil are insignificant for deer mouse and red-tailed hawk.

1.2.5.3 Congener-Specific Risk Assessment Addendum

An addendum to the Final BERA and Final HHRA that presents the congener-specific approach for assessing PCB-related risks at the Site was prepared for FWP (CDM, 2008). In this approach, each PCB congener is measured and evaluated with regard to its toxicity relative to the most toxic dioxin congener, 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD). This approach is based on the assumption that most of the adverse effects from PCB exposure are due to dioxin-like effects. The results of the addendum to the Final BERA and HHRA are presented below.

Data Collection. In order to support the congener-specific approach, samples of paint chips (red and blue/green), Big Spring Creek sediment, and rainbow and brown trout (and eggs) were collected in winter, spring, and summer of 2005, and analyzed for Aroclor 1254, and individual

DRAFT

PCB, dioxin, and furan congeners known to exhibit 2,3,7,8-TCDD-like activity. Reaches 3 and 6, as described in the final risk assessments, were subject to additional fish sampling. Additional sediment samples were collected from Reaches 2, 3, and 4, which are the reaches with the highest sediment PCB levels as determined in the final risk assessments.

The results of analyses of sediment and paint revealed that up to two PCB congeners, two dioxin congeners, and nine furan congeners were detected in one or more paint or sediment samples. Six PCB congeners were detected in the various fish tissues analyzed. Dioxins and furans were not detected in fish tissues; however, one furan was detected in rainbow trout eggs. Three PCB congeners were detected in rainbow trout eggs and two were detected in eggs of brown trout.

Ecological Risk Assessment. The Addendum focused on the most important and, based on the Final BERA, the potentially most at-risk ecological receptors, which are trout and mink. Mink are very sensitive to PCBs, dioxins, and furans, and ingestion of fish is the exposure pathway of most concern for mink. Protection of mink is assumed to provide protection for other less sensitive ecological receptors. Trout were selected as key receptors for this analysis because maintaining or enhancing trout survival, growth, and reproduction in Big Spring Creek will provide a multitude of ecological, social, and economic benefits. Data on whole body trout contaminant residues were used to assess risks to mink and trout, while trout egg data were used to assess risks to early life stage trout.

The analysis found that risks to trout are insignificant to very low (highest HQ=2.3) using the Aroclor 1254 approach and insignificant (HQ<1) in all cases using the congener-specific approach. For mink, risks are elevated using either approach, but only for Reach 3. All risk estimates for Reach 6 have an HQ value less than 1. These results suggest that any further investigations into ecological risk or possible needs to reduce existing risks can be focused on only the most contaminated portions of Big Spring Creek, represented in the Addendum by Reach 3.

Human Health Risk Assessment. In the Addendum, both cancer and non-cancer health hazards from exposure to PCBs for people fishing or recreating on or near the Site are quantitatively evaluated using the congener-specific approach. Potential exposures to dioxins/furans are also evaluated for sport anglers. Site-specific exposure parameters and assumptions based on community input and Site investigations were incorporated into this assessment.

The analysis supports the conclusions of the final HHRA (CDM, 2005). Eating fish taken from the creek, particularly in the reaches just below the hatchery is the primary pathway in which humans might be exposed to PCBs from Big Spring Creek. Under the assumptions for the sport angler, the excess cancer risk may be up to an order of magnitude higher than EPAs “acceptable range”. Both approaches used to evaluate potential exposures in this addendum indicate that cancer risk associated with ingestion of fish may be unacceptable in Reach 3. Cancer risk estimates for Reach 3 using the congener-specific approach (2×10^{-4} to 1×10^{-3}) are higher than when using the Aroclor 1254 approach (1×10^{-4} to 4×10^{-4}). Cancer risk estimates for Reach 6 are within EPA’s “acceptable range” under both the congener-specific and the Aroclor 1254 approach. For non-cancer effects, the consumption of fish by the sport angler results in a level of exposure to PCBs that could be as great as 25 times higher than the EPA reference level of one. It is important to note that risks may be overestimated for the sport angler. Both cancer and non-cancer risks are conservative in the sense that they assume the angler consumes 24 meals per year for 30 years. Risks shown for each reach assume the

DRAFT

angler consumes fish exclusively from this area of the stream for 30 years. Risks would be lower if the angler consumed fish from other areas, from non-contaminated waterbodies, or at lower rates of consumption.

Risks from being exposed to PCBs in Big Spring Creek through incidental ingestion and dermal contact with contaminated sediments are significantly below EPA's levels of concern for cancer and non-cancer health effects based on a recreational scenario for all areas evaluated.

1.2.5.4 Risk-Based Fish Fillet HHRA Supplement

A 2009 supplement to the HHRA (CDM, 2009) considered the calculation of concentrations of dioxin-like PCB congeners and 2,3,7,8-substituted chlorinated dioxin/furan congeners in fish tissue that are associated with cancer risks defined by the USEPA risk range of 10^{-6} to 10^{-4}. The HHRA supplement was completed in accordance with the methodologies and exposure assumptions identified for the Big Spring Creek HHRA (CDM, 2005) and the Addendum to the HHRA (CDM, 2008). The supplement was developed to aid the process of updating fish advisories for Big Spring Creek.

The supplement continued the work of the Addendum (Section 1.2.5.3) by providing risk-based fish fillet concentrations protective for a range of cancer risks ($1x10^{-4}$ to $1x10^{-6}$) for dioxin-like PCB and dioxin/furan congeners. Risk-based concentrations are expressed as TCDD toxicity equivalents, or TCDD TEQ, as described in the HHRA addendum. Risk-based concentrations were estimated for a range of fish meals per month using the approach and exposure assumptions presented in the Baseline HHRA (CDM, 2005).

In addition, ratios of Aroclors to TCDD TEQ concentrations in trout tissue (fillet) were used to convert risk-based concentration in TEQ to concentrations of Aroclors (total PCBs). The latter concentrations are routinely used to characterize fish tissue contamination for Big Spring Creek. Thus, fish advisories are best expressed in terms of Aroclor concentrations. Table 8 presents risk-based fish tissue concentrations that are protective for human consumption based on the number of meals per month and the cancer risk. The risk-based tissue concentrations are based on Aroclors.

DRAFT

1.2.6 Media and Contaminants of Concern

Identifying the media, exposure routes, and contaminants of concern is a prerequisite to developing remedial action objectives during the Feasibility Study. The Final Baseline Ecological Risk Assessment (BERA) and Final Human Health Risk Assessments (HHRA) prepared for FWP (CDM, 2005) were used to develop the media and contaminants of concern. The BERA initially identified surface water, instream sediment, floodplain sediment (or riparian surface soil), benthic macroinvertebrates, and fish as potential media of concern and PCB Aroclor-1254 and copper as contaminants of concern (CoCs); however, the results of the BERA showed that only Aroclor-1254 warrants consideration with regard to possible remediation, and the only media of concern that were identified are instream sediment and biota (e.g., fish and benthic macroinvertebrates) in Reaches 2, 3, and 4. The results of the BERA and HHRA are discussed in Section 1.2.5.

The physical characteristics and health information related to PCBs have been summarized by the Agency for Toxic Substances and Disease Registry (ATSDR) in a frequently asked questions (FAQ) format through ATSDR's ToxFAQs™. The ToxFAQs™ for PCBs is based on the ATSDR toxicological profile for PCBs (ATSDR, 2000). Information from the ToxFAQs™ for PCBs is presented in Appendix C.

1.2.7 Treatability Studies

An opportunity arose in fall 2006 to complete a pilot test of a small suction dredge system operated by Streamside Systems, LLC. Streamside Systems happened to be working in the area and offered to demonstrate their "Sand Wand" technology. The "Sand Wand" is a portable system that consists of a suction head equipped with a one-inch diameter water jet that pumps at a rate of approximately 90 gallons per minute, and a three-inch diameter suction hose to remove the fine materials dislodged by the action of the water jet. The suction hose operates at a flow rate of approximately 340 gallons per minute. Support equipment and services, including concrete barriers, a 10,000-gallon frac tank, and disposal of the collected water and sediment, were provided by FWP.

Important issues evaluated during this demonstration were: 1) the efficiency of the dredge at removing sediment and paint chip particles both at the surface and at greater depths; 2) the speed of the system, i.e. the rate of removal of sediment and paint chips; 3) the collateral damage to stream banks and vegetation at the Site; 4) logistical issues that occur as a result of the dredging, e.g. time to setup, ability to control suspended sediment, space required for trailers, pumps and vehicles. A detailed description of the pilot test was provided by FWP (FWP, 2007) and is included in Appendix D.

Results of the pilot test show that about 91% of the PCBs were estimated to have been removed from the sediment down to a depth of 5-7 inches (FWP, 2007). The implications of this for aquatic life, and especially fish, can only be estimated after making several assumptions. One assumption is that the PCBs available for uptake by aquatic life are those in the surficial sediments, probably closely represented by the data here from depths of 5-7 inches. PCBs in deeper sediments are probably not bioavailable. It is also assumed that most if not all of these PCBs have remained bound up in the paint chips. A final assumption is that smaller sizes of paint chips are more bioavailable to aquatic invertebrates (and fish via the food chain) than are large paint chips. Based on these three assumptions, it is likely that a removal of 91% of the paint chips will translate to lower levels of PCBs in aquatic insects and fish muscle. Even though the action of the dredge appears to break up paint chips into small size fractions (and hence make them more bioavailable), the pilot test results show that the amount of paint chips in small size fractions is still substantially decreased in sediments from dredged areas relative to sediments from undredged areas.

The demonstration by Streamside Systems personnel lasted about two hours, although the actual time that the dredge was in operation was estimated to be close to one hour. In this time, 60-75 square feet were dredged and 1,400 pounds of sediment (dry weight basis) were removed. Because of the short duration, it is difficult to determine if this would be a typical dredge rate during a full-scale operation. Factors which would slow the operation include large, heavily armored substrate which is not easily dislodged by the water jet or low-hanging heavy vegetation which hinders movement. The presence of beds of aquatic macrophytes is difficult for this system to handle because the plants tend to clog the suction hose. During the pilot test, 10-15 minutes was expended raking the streambottom to dislodge the rooted vegetation in advance of dredging activities. One factor which might speed up the operation include an

DRAFT

operator with experience at the site who is able to fine-tune the flow rates used for the water jet and suction pump.

No other treatability studies were proposed in the FS work plan and no other treatability studies were completed during the FS. No samples beyond those described above were collected to support the FS activities.

1.2.8 Deviations from the FS Work Plan

There were no deviations from the scope of work outlined in the FS work plan.

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2.0 Summary of the Applicable Or Relevant and Appropriate Requirements

Section 121(d) of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) stipulates that remedial actions instituted under the Superfund program comply with ARARs. Consideration must also be given to relevant information that, while not legally binding, is collectively referred to as To Be Considered (TBC) information. ARARs are promulgated cleanup standards and other environmental protection requirements, criteria, or limitations contained within local, state, and federal laws and regulations. TBCs may or may not be promulgated standards and not legally enforceable. Nevertheless, TBCs may contribute to the development and implementation of effective and protective remedial alternatives.

The identification of ARARs and TBCs depends on the media, CoCs, site-specific characteristics, and the technologies employed during remediation. ARARs and TBCs that may contribute to defining remedial alternatives for Big Spring Creek PCB project area are provided in Appendix E and are grouped into chemical-specific, location-specific, and action-specific categories.

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3.0 Identification and Screening of Technologies

3.1 Remedial Action Objectives and Preliminary Remediation Goals

The primary objective of remediation in the project area is to protect human health and the environment in accordance with the guidelines set forth by the Toxic Substances Control Act (TSCA), CERCLA, and the National Contingency Plan (NCP) (EPA, 1990), as well as applicable State law, including the Comprehensive Environmental Cleanup and Responsibility Act (CECRA).

3.1.1 Remedial Action Objectives

The results of the risk assessments completed by FWP (CDM, 2005 and 2008) suggest that only PCB warrants consideration with regard to possible remediation, and the media of concern appear to be instream sediments and biota (e.g., fish and benthic macroinvertebrates) contaminated with PCBs. As such, the Remedial Action Objectives (RAOs) for PCBs in Big Spring Creek are:

1. Reductions in PCB concentrations in fish such that human consumption restrictions can be lifted.

2. The establishment and maintenance of a healthy and diverse aquatic and riparian ecosystem in and adjacent to Big Spring Creek.

A goal of the RI/FS is to develop site-specific remediation targets for sediments that can be expected to achieve these goals. Previous attempts to develop site-specific remediation targets for sediment have resulted in poor correlation between PCB concentrations in fish tissue and PCB concentrations in sediment. Likely reasons for the poor correlation include a relatively small sample size, migration patterns and diet differences of fish that result in varying exposures, and other potential factors in the sediments that are affecting the bioavailability of PCBs such as the amount of organic matter, or size and density of PCB-laden paint chips. Additional fish tissue and PCB concentration data have been collected by FWP and these data will be evaluated during the RI/FS process.

DRAFT

3.1.2 Preliminary Remedial Goals

Preliminary Remediation Goals (PRGs) were developed in the FSWP (Olympus, 2008a) and in the RI (Olympus, 2009), and are summarized in the following sections.

3.1.2.1 ARAR Based Preliminary Remediation Goals

The state of Montana has not developed cleanup levels for PCBs in stream sediment. According to U.S. EPA regulations, PCB-impacted stream sediments at the Site can be considered a PCB remediation waste since the PCBs are present as a result of a release to the environment (Title 40 CFR 761.3). The cleanup level for PCB Remediation Waste in high occupancy areas is less than or equal to 1 part per million (Title 40 CFR 761.61(a)(4)(i)(A)).

The EPA regional administrator may also require cleanup to more stringent levels based on proximity to areas such as residences, wetlands, fisheries, etc. Cleanup levels for PCBs at other contaminated sites from around the U.S. were reviewed through the Cleanup Level Corporation database (Cleanup Level Corporation, 2006), which is provided in Appendix F. The review was restricted to cleanup levels developed in 1998 or later since major changes to PCB regulations occurred in 1998. Thirty three sites were listed in the database with cleanup levels ranging from 0.49 to 500 parts per million PCBs in soil and sediment. Cleanup levels were mostly from risk-based guidance and covered a variety of situations.

3.1.2.2 Risk-Based Cleanup Goals

The BERA (CDM, 2005) developed a range of possible clean-up criteria or risk-based concentrations (RBCs) for several important receptors that could be applied to the remedial action objective (RAO) of establishing and maintaining a healthy and diverse aquatic and riparian ecosystem as proposed in the FSWP (Olympus, 2008a). For all sediments that can be assumed to be part of the aquatic environment, RBCs based on protection of most benthic macroinvertebrates is 676 µg/kg, and for protection of insectivorous birds the RBC is 1,600 µg/kg (marsh wren).

The range of RBCs based on protection of most aquatic and upland species is not greatly different than the range of RBCs developed based on risks and hazards to human health. The HHRA cites a range of 240 to 2,560 µg/kg for RBCs for sport anglers, which overlaps substantially with the range of RBCs for aquatic and riparian receptors (676 to 1,600 µg/kg). The BERA notes that, due to uncertainties in the estimates of RBCs for protection of human health, an RBC based on macroinvertebrates may be the most reliable for general protection within the ecosystem. In any case, protection of both human and ecological receptors should be achievable using much the same target sediment values.

In the TMDL plan for Big Spring Creek (DEQ, 2005), DEQ used a provisional target for PCBs in benthic sediment aimed at protecting aquatic life beneficial uses. DEQ chose the probable effects level developed by EPA (1997), which requires the average Aroclor 1254 concentration to be less than 189 µg/kg. The TMDL target value of 189 µg/kg has been adopted as the project screening level for PCBs in stream sediment (Olympus, 2007).

The National Oceanic and Atmospheric Administration (NOAA) has developed Screening Quick Reference Tables (SQuiRTs) that provide screening concentrations for inorganic and organic contaminants in various environmental media, including freshwater sediment (Buchman, 2008). The screening concentration for PCBs (Aroclor 1254) at the Probable Effects Level (PEL) is 340 µg/kg (parts per billion). Prior to 2008, the SQuiRTs did not have a specific PEL for PCB Aroclor 1254 and the PEL for total PCBs was 277 µg/kg.

3.1.2.3 PRGs Based on Fish Tissue/Sediment Data

PRGs based on the concurrent fish tissue and stream sediment data collected by FWP were developed and presented in the RI report (Olympus, 2009). These samples resulted in the development of a fish tissue/stream sediment relationship as presented on Figure 18. The Department of Public Health and Human Services (DPHHS) has developed meal guidelines for the consumption of fish contaminated with PCBs (DPHHS, 2002) as shown in Table 9. The fish tissue and sediment relationships, along with the risk assessment supplement data can be used

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to estimate the PCB concentrations in sediment that may be required to meet meal guidelines for consumption of fish.

The fish tissue/sediment relationship was used estimate the sediment concentrations that would correspond to threshold fish tissue values for the meal advisory standards. Table 10 presents the stream sediment PCB concentrations that would likely need to be achieved, based on the fish tissue/stream sediment relationship (Figure 18), in order to meet the generic DPHHS meal guidelines for rainbow and brown trout, respectively. To achieve a fish tissue PCB concentration of 0.025 mg/kg (unlimited consumption) would require sediment PCB concentrations to be well below typical analytical detection limits for PCBs for both rainbow and brown trout. The typical detection limit for the Phase 1 stream sediment sampling was 20 µg/kg. To achieve a fish tissue PCB concentration of less than 0.10 mg/kg (1 meal/week) would require a sediment PCB concentration of approximately 40 µg/kg for rainbow trout and 22 µg/kg for brown trout, which is at or only slightly above typical detection limits. To achieve a fish tissue PCB concentration of less than 0.47 mg/kg (1 meal/month) would require a sediment PCB concentration of 264 µg/kg for rainbow trout and 58 µg/kg for brown trout.

The fish tissue/sediment relationship was also used to estimate the sediment concentrations that would likely be required to achieve the meal guidelines and cancer risk targets from the risk assessment supplement. Table 11 presents sediment concentrations calculated from the fish sediment relationship (Figure 18) that would likely be required to meet the risk-based fish tissue PCB concentrations that are protective for cancer risks of 10^{-4}, 10^{-5}, and 10^{-6}. These data indicate that sediment PCB concentrations would need to be below method SW8082 analytical detection limits in order to allow more than one meal per month of both rainbow and brown trout at a cancer risk of 10^{-5}. Sediment PCB concentrations at the screening level of 189 µg/kg would correlate to a 3 to 4 meals per month at a cancer risk of 10^{-4}.

The data in Table 10 and Table 11 indicate that achieving unlimited fish consumption would require removing virtually all of the PCBs from Big Spring Creek, especially in the case of rainbow trout. Since these sediment PCB concentrations are less than the typical analytical detection limit for PCB analyses, these concentrations will not be measurable in sediment and can only be tracked through monitoring fish tissue PCB concentrations.

The 2005 hatchery cleanup appears to have resulted in lower concentrations in both stream sediment and fish tissue. These results were likely the result of “drifting” PCB sources other than paint chips, such as algae and/or fish waste that were formerly discharged from the hatchery. Removal of sediment from the upper portion of Big Spring Creek (particularly fine sediment) may provide a similar benefit by removing additional “drifting” sources of highly bio-available PCBs. If these drifting sources are occurring in the upper creek, and adding to the PCB concentration in fish tissue, removal of this potential source may further reduce PCB concentrations in downstream fish; however, this cannot be quantified at this time.

3.2 General Response Actions

General response actions are categories of actions that may be implemented to achieve the project-specific remedial action objectives. General response actions may include (but are not limited to) such categories as treatment, containment, disposal, or combinations of these categories. General response actions identified for potential remediation of the Big Spring Creek PCB-impacted sediment (Olympus, 2008a) include the following:

DRAFT

- No Action;
- Monitored Natural Recovery;
- Institutional Controls;
- Containment;
- In Situ Treatment;
- Removal;
- Ex Situ Treatment; and
- Disposal.

3.3 Identification and Screening of Technology Types and Process Options

3.3.1 Identification and Screening of Treatment Technologies

Various remediation technologies were evaluated and screened in the FSWP (Olympus, 2008a) using the information provided by the Federal Remediation Technologies Roundtable (FRTR) Remedial Technologies Screening Matrix (FRTR, 2008). That evaluation is repeated here for continuity and clarity. The FRTR is a collaboration among federal agencies involved in hazardous waste site cleanup, including the U.S. Department of Defense, EPA, Department of Energy, Department of the Interior, and National Aeronautics and Space Administration. The screening matrix lists biodegradation, dehalogenation, incineration, and excavation with off-site disposal as common treatment technologies for halogenated SVOCs (which includes PCBs) in soil, sediment, and sludge.

Various treatment technologies are rated by the FRTR as above average, average, or below average based on the following factors:

- development status,
- treatment train,
- overall cost and performance (O&M; capital; system reliability and maintainability; relative cost; and cleanup time),
- availability of the technology, and
- contaminants treated.

Table 12 presents a screening matrix for treatment technologies considered by FRTR (2008). A remediation technology was retained for further screening if it was rated average or above average for development status, treatment train, and demonstration with the contaminant to be treated. Availability of the technology and overall cost and performance are considered in subsequent screening. Of the 28 technologies listed by FRTR for potential treatment of soil, sediment, and sludge, 13 did not meet the minimum requirements and were screened out as shown in Table 12.

3.3.2 Identification and Screening of Remediation Technologies and Process Options

To facilitate the evaluation, the general response actions identified in Section 3.2 were further divided into remediation technology types and process options. Various remediation technologies and process options were evaluated and screened in the Initial Alternatives Screening Document (IASD - Olympus, 2008b). The purpose of identifying and screening remediation technology types and processes was to eliminate those technologies and process

DRAFT

options that are not feasible. The screening criteria included technical implementability, effectiveness and cost.

Implementability

Implementability encompasses both the technical and administrative feasibility of implementing a technology process. Technical implementability is used as an initial screen of technology types and process options to eliminate those that are clearly ineffective or unworkable at a site. Therefore, this subsequent, more detailed evaluation of process options places greater emphasis on the institutional aspects of implementability, such as the ability to obtain necessary permits for offsite actions, the availability of treatment, storage, and disposal services (including capacity), and the availability of necessary equipment and skilled workers to implement the technology.

Effectiveness

Specific technology processes that have been identified are evaluated further based on their effectiveness relative to other processes within the same technology type. This evaluation should focus on: (1) the potential effectiveness of process options in handling the estimated areas or volumes of media and meeting the remediation goals identified in the remedial action objectives; (2) the potential impacts to human health and the environment during the construction and implementation phase; and (3) how proven and reliable the process is with respect to the contaminants and conditions at the Site.

Cost

Cost plays a limited role in the initial screening of process options. Relative capital and O&M costs are used rather than detailed estimates. At this stage in the process, the cost analysis is made on the basis of engineering judgment, and each process is evaluated as to whether costs are high, low, or medium relative to other process options in the same technology type. The greatest cost consequences in site remediation are usually associated with the degree to which different general technology types (i.e., containment, treatment, excavation, etc.) are used. Using different process options within a technology type usually has a less significant effect on cost than does the use of different technology types.

Only treatment technologies that were retained in Table 12 were considered in the screening of general response actions and remediation technologies. The technologies presented were grouped by general response actions. Table 13 presents the general response actions, remediation technologies, and process options that were evaluated, and summarizes the results of the screening process.

Technologies and process options were first screened on the basis of technical implementability. Technologies and process options that were deemed technically implementable were further screened on the basis of effectiveness and relative cost. Process options retained after initial screening in Table 13 were subjected to an expanded screening in Section 3.4.

DRAFT

3.4 Screening of Process Options

The general response actions, remediation technologies, and process options that were retained after initial screening are summarized in Table 14. The following sections provide additional information about each of these process options, as they are applicable to in-stream sediment. These discussions have been derived from EPA (2005), which is specific to stream sediment remediation, and from FRTR (2008).

The following sections provide more detailed descriptions of each process option and provide expanded evaluations based on the criteria of implementability, effectiveness, and cost. Costs are described in terms of relative capital and O&M rather than detailed estimates. Detailed cost estimates were prepared for remediation alternatives that undergo detailed analyses and are presented in Section 5.0.

3.4.1 No Action

DRAFT

General - The NCP at Title 40 Code of Federal Regulations (40 CFR) §300.430(e)(6) provides that the no-action alternative should be considered at every site. The no action alternative should reflect the site conditions described in the baseline risk assessment and remedial investigation. This alternative may be a no-further-action alternative if some removal or remedial action has already occurred at the site.

No-action or no-further-action alternatives normally do not include any treatment, engineering controls, or institutional controls but may include monitoring. For example, at a site where risk is acceptable (e.g., because contaminant levels in surface sediment and biota are low and the site is stable), but the site contains higher levels of contamination at depth, it may be advisable to evaluate periodically the continued stability of buried contaminants. A no action alternative may include monitoring of these buried contaminants. The no action alternative should not be confused with Monitored Natural Recovery (MNR), where natural processes are relied upon to reduce an unacceptable risk to acceptable levels. The difference is often the increased level and frequency of monitoring included in the MNR alternative and the fact that the MNR alternative includes a cleanup level and expected time frame for achieving that level. It is normal to evaluate both a no action alternative and a MNR alternative at sediment sites (EPA, 2005).

If a no-action or no-further-action alternative does not meet the NCP's threshold criteria addressed in 40 CFR §300.430 (i.e., protection of human health and the environment and meeting applicable or relevant and appropriate requirements), it is not necessary to carry it through to the detailed analysis of alternatives; however, the record of decision (ROD) or action memorandum should explain why the no action alternative was dropped from the analysis.

The no action alternative means that no remediation is completed at the site to control contaminant migration or to reduce toxicity or volume. This option would require no further investigation or remediation at the site. Periodic monitoring would likely continue per the TMDL program (DEQ, 2005).

Effectiveness - Toxicity, mobility, and volume of contaminants would not be reduced under the no action alternative. Also, protection of human health and the environment would not be achieved under this alternative. The remedial investigation data indicated that in-stream sediment and biota have been impacted by PCBs. Although PCB concentrations in fish tissue have declined since the PCB removal action was implemented at the lower hatchery, there is no indication that PCB concentrations will decrease to levels that will meet the RAOs. Additionally, the no action alternative does not address PCBs in stream sediment, which would continue to be a source of PCB exposure to human and ecological receptors.

Implementability - Technical and administrative feasibility evaluation criteria do not apply to this alternative.

Cost Screening - No capital or operating costs would be incurred under this alternative. However, monitoring per the TMDL plan (DEQ, 2005) would likely continue. Costs associated with the monitoring would be low compared to other process options.

Screening Summary - The no action response is generally used as a baseline against which other remediation options can be compared. This alternative has been retained for further evaluation as suggested by the NCP.

3.4.2 Monitored Natural Recovery

General - MNR is a remedy for contaminated sediment that typically uses ongoing, naturally occurring processes to contain, destroy, or reduce the bioavailability or toxicity of contaminants in sediment. Not all natural processes result in risk reduction; some may increase or shift risk to other locations or receptors. MNR may rely on a wide range of naturally occurring processes to reduce risk to human and/or ecological receptors. These processes may include physical, biological, and chemical mechanisms that act together to reduce the risk posed by the contaminants. Depending on the contaminants and the environment, this risk reduction may occur in a number of different ways. Many different natural processes may reduce risk from contaminated sediment, including the following, listed from generally most to least preferable, though all are potentially acceptable, as a basis for selecting MNR:

1. The contaminant is converted to a less toxic form through transformation processes, such as biodegradation or abiotic transformations.

2. Contaminant mobility and bioavailability are reduced through sorption or other processes binding contaminants to the sediment matrix.

3. Exposure levels are reduced by a decrease in contaminant concentration levels in the near-surface sediment zone through burial or mixing-in-place with cleaner sediment.

4. Exposure levels are reduced by a decrease in contaminant concentration levels in the near-surface sediment zone through dispersion of particle-bound contaminants or diffusive or advective transport of contaminants to the water column.

Natural processes that reduce toxicity through transformation or reduce bioavailability through increased sorption are usually preferable as a basis for remedy selection to mechanisms that reduce exposure through natural burial or mixing-in-place because the destructive/sorptive mechanisms generally have a higher degree of permanence. However, many contaminants that remain in sediment are not easily transformed or destroyed. For this reason, risk reduction due to natural burial through sedimentation is more common and can be an acceptable sediment management option. Dispersion is the least preferable basis for remedy selection based on MNR. While dispersion may reduce risk in the source area, it generally increases

DRAFT

exposure to contaminants and may result in unacceptable risks to downstream areas or other receiving water bodies. The effects of this increased exposure and risk to receiving water bodies should be carefully evaluated before selecting MNR where dispersion is one of the risk reduction mechanisms, to ensure that it is not simply transferring risk to a new area.

To select a MNR remedy, the need for the following should generally be considered:

- A detailed understanding of the natural processes that are affecting sediment and contaminants at the site;
- A predictive tool (generally based either on computer modeling or extrapolation of empirical data) to predict future effects of those processes;
- A means to control any significant ongoing contaminant sources;
- An evaluation of ongoing risks during the recovery period and exposure control, where possible; and
- The ability to monitor the natural processes and/or concentrations of contaminants in sediment or biota to see if recovery is occurring at the expected rate.

MNR should receive detailed consideration where the following site conditions are present (EPA, 2005):

- Anticipated land uses or new structures are not incompatible with natural recovery;
- Natural recovery processes have a reasonable degree of certainty to continue at rates that will contain, destroy, or reduce the bioavailability or toxicity of contaminants within an acceptable time frame;
- Expected human exposure is low and/or can be reasonably controlled by institutional controls;
- Sediment bed is reasonably stable and likely to remain so;
- Sediment is resistant to resuspension (e.g., cohesive or well-armored sediment);
- Contaminant concentrations in biota and in the biologically active zone of sediment are moving towards risk-based goals on their own;
- Contaminants already readily biodegrade or transform to lower toxicity forms;
- Contaminant concentrations are low and cover diffuse areas; and
- Contaminants have low ability to bioaccumulate.

Some consider that all sediment site remedies are using natural recovery to some extent because natural processes are ongoing whether or not an active cleanup is underway [e.g., National Research Council (NRC) 2001]. It is true that natural processes in most cases will continue whether or not an active cleanup is underway, but these processes may either reduce, transfer, or increase risk. Natural processes may reduce residual risk following dredging or in-

DRAFT

situ capping at many sites, and it can be very valuable to monitor further risk reduction. The key factors that normally distinguish MNR as a remedy are the presence of unacceptable risk, the ongoing burial or degradation/transformation, or dispersion of the contaminant, and the establishment of a cleanup level that MNR is expected to meet within a particular time frame.

MNR has been selected as a component of the remedy for contaminated sediment at approximately one dozen Superfund sites (EPA, 2005). Historically, at many sites MNR has been combined with dredging or in-situ capping of other areas of a site. When hazardous substances left in place are above levels that allow for unlimited use and unrestricted exposure, a five-year review pursuant to Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) §121(c) may be required (U.S. EPA, 2001).

Two key limitations of MNR may include that it generally leaves contaminants in place and that it can be slow in reducing risks in comparison to active remedies. Any remedy that leaves untreated contaminants in place probably includes some risk of reexposure of the contaminants. When MNR is based primarily on natural burial, there is some risk of buried contaminants being reexposed or dispersed if the sediment bed is significantly disturbed by unexpectedly strong natural or man-made (anthropogenic) forces. The potential effects of reexposure may be greater if high concentrations of contaminants remain in the sediment, and likewise, lower if contaminant concentrations or risks are low.

<u>Effectiveness</u> - MNR depends on natural biological, chemical and/or physical processes to reduce the volume and toxicity of contaminants; however, paint chips have been in the stream sediment and have been exposed to natural processes for a number of decades. Based on the results of the Phase 1 and Herrera stream sediment sampling efforts, and the FWP fish tissue and sediment sampling, PCBs in stream sediment and fish tissue are still at concentrations that exceed screening levels. Thus, it appears that MNR is not viable as a stand-alone solution for the remediation of Big Spring Creek. MNR may be a viable solution for portions of the project area if implemented in conjunction with other process options that involve partial removal of impacted sediment from portions of the creek.

<u>Implementability</u> - MNR is both technically and administratively implementable. No permits, (i.e., 404, 124, storm water, etc.) should be required since no construction activity would be conducted. The sampling and laboratory analysis required for MNR are considered standard in the environmental field and there are adequate laboratories and sampling personnel available to implement the technology.

<u>Cost</u> - Costs associated with MNR would generally be low compared to other process options, except for the no action alternative.

<u>Screening Summary</u> - Based on the preceding discussion, MNR will not be considered as a stand-alone alternative for remediation of Big Spring Creek sediment. MNR may be considered for portions of Big Spring Creek in conjunction with partial sediment removal actions (i.e., excavation or dredging).

3.4.3 Institutional Controls

<u>General</u> - The term “institutional control” (IC) generally refers to non-engineering measures intended to affect human activities in such a way as to prevent or reduce exposure to hazardous substances, often by limiting land or resource use. ICs can be used at all stages of the remedial

DRAFT

process to reduce exposure to contamination. EPA (2005) offers guidance on when it may be appropriate to select a remedy that includes institutional controls at sediment sites and considerations regarding their effectiveness and enforceability.

The following are the four general categories of ICs (EPA, 2000):

- Governmental controls;
- Proprietary controls;
- Enforcement and permit tools with IC components; and
- Information devices

Usually, governmental controls (e.g., bans on harvesting fish and catch and release only fishing regulations) are implemented and enforced by the state or local government. Proprietary controls (often referred to as "deed restrictions"), such as easements or covenants, typically involve legal instruments placed in the chain of title of the site or property. Where enforcement tools are used to implement ICs, they may include provisions of CERCLA Unilateral Administrative Orders (UAOs), Administrative Orders on Consent (AOCs), or Consent Decrees (CD). Information devices are designed to provide information or notification to the public. The three most common types of ICs at sediment sites include fish consumption advisories and commercial fishing bans, waterway use restrictions, and land use restriction/structure maintenance agreements (EPA, 2005).

Fish consumption advisories are already in place at the site, as well as catch and release only fishing regulations. Fish consumption advisories are informational devices that are frequently already in place and incorporated into sediment site remedies. Commercial fishing bans and catch and release only fishing regulations are government controls that ban commercial fishing for specific species or sizes of fish or shellfish or prohibit fish removal. Usually, state departments of health are the governmental entities that establishes these advisories and bans. Frequently, fish consumption advisories and fishing bans are in place before a site is listed on the NPL, but if not, it could be necessary for the state to issue or revise them in conjunction with an early or interim action, or the final remedial action. An advisory usually consists of informing the public that they should not consume fish from an area, or consume no more than a specified number of fish meals over a specific period of time from a particular area. Sensitive sub-populations or subsistence fishers may be subject to more stringent advisories. Advisories can be publicized through signs at popular fishing locations, pamphlets, or other educational outreach materials and programs.

DRAFT

<u>Effectiveness</u> - Toxicity, mobility, and volume of contaminants would not be reduced using institutional controls. Human health would be protected only to the degree that the public adheres to consumption advisories and comply with restrictive fishing regulations such as catch and release, seasonal closures, size restrictions, or harvest limitations. Institutional controls provide no protection for ecological receptors.

<u>Implementability</u> - Institutional controls are easily implemented from a technical standpoint. Institutional controls are easily implemented from an administrative standpoint; however, the ability to enforce institutional controls such as consumption advisories is questionable.

<u>Cost</u> - Capital or operating costs incurred under this process option would be minimal compared to other alternatives. However, monitoring per the TMDL plan (DEQ, 2005) would likely continue. Costs associated with the monitoring would be low compared to other process options.

Screening Summary - Based on the limited effectiveness, institutional controls will not be considered as a stand-alone alternative for remediation of Big Spring Creek sediment. The existing institutional controls (fish consumption advisory and catch and release only fishing regulations) will likely remain in effect until such time that PCB concentrations in fish tissue have decreased to acceptable levels for removal of these controls.

3.4.4 In-Situ Capping

General - In-situ capping refers to the placement of a subaqueous covering or cap of clean material over contaminated sediment that remains in place (EPA, 2005). Caps are generally constructed of granular material, such as clean sediment, sand, or gravel. A more complex cap design can include geotextiles, liners, and other permeable or impermeable elements in multiple layers that may include additions of material to attenuate the flux of contaminants (e.g., organic carbon). Depending on the contaminants and sediment environment, a cap is designed to reduce risk through the following primary functions:

- Physical isolation of the contaminated sediment sufficient to reduce exposure due to direct contact and to reduce the ability of burrowing organisms to move contaminants to the surface;
- Stabilization of contaminated sediment and erosion protection of sediment and cap, sufficient to reduce resuspension and transport to other sites; and/or
- Chemical isolation of contaminated sediment sufficient to reduce exposure from dissolved and colloidally bound contaminants transported into the water column.

As of 2004, in-situ capping has been selected as a component of the remedy for contaminated sediment at approximately fifteen Superfund sites (EPA, 2005). At some sites, in-situ capping has served as the primary approach for sediment, and at other sites it has been combined with sediment removal (i.e., dredging or excavation) and/or MNR of other sediment areas. When hazardous substances left in place are above levels allowing for unlimited use and unrestricted exposure, a five-year review pursuant to the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) §121(c) may be required (U.S. EPA 2001).

Capping is sometimes considered following partial sediment removal where capping alone is not feasible due to a need to preserve a minimum water body depth for navigation or flood control, or where it is desirable to leave deeper contaminated sediment in place to preserve bank or shoreline stability following removal. Application of thin layers of clean material may be used to enhance natural recovery through burial and mixing with clean sediment when natural sedimentation rates are not sufficient.

Placement of a thin layer of clean material is also sometimes used to backfill dredged areas, where it mixes with dredging residuals and further reduces risk from contamination that remains after dredging. In this application, the material is not often designed to act as an engineered cap to isolate buried contaminants and is, therefore, not considered by EPA to be in-situ capping (EPA, 2005).

Capping should receive detailed consideration where the following site conditions are present (EPA, 2005):

DRAFT

- Suitable types and quantities of cap material are readily available
- Anticipated infrastructure needs (e.g., piers, pilings, buried cables) are compatible with cap
- Water depth is adequate to accommodate cap with anticipated uses (e.g., navigation, flood control)
- Incidence of cap-disrupting human behavior, such as large boat anchoring, is low or controllable
- Long-term risk reduction outweighs habitat disruption, and/or habitat improvements are provided by the cap
- Hydrodynamic conditions (e.g., floods, ice scour) are not likely to compromise cap or can be accommodated in design
- Rates of ground water flow in cap area are low and not likely to create unacceptable contaminant releases
- Sediment has sufficient strength to support cap (e.g., higher density/lower water content, depending on placement method)
- Contaminants have low rates of flux through cap
- Contamination covers contiguous areas (e.g., to simplify capping)

Two advantages of in-situ capping are that it can quickly reduce exposure to contaminants and that, unlike dredging or excavation, it requires less infrastructure in terms of material handling, dewatering, treatment, and disposal. A well-designed and well-placed cap should more quickly reduce the exposure of fish and other biota to contaminated sediment as compared to dredging, as there should be no or very little contaminant residual on the surface of the cap.

The major limitation of in-situ capping is that contaminated sediment remains in the aquatic environment where contaminants could become exposed or be dispersed if the cap is significantly disturbed or if contaminants move through the cap in significant amounts. In addition, in some environments, it can be difficult to place a cap without significant contaminant losses from compaction and disruption of the underlying sediment. Another potential limitation of in-situ capping may be in some situations, a preferred habitat may not be provided by the surficial cap materials. To provide erosion protection, it may be necessary to use coarse cap materials that are different from native soft bottom materials, which may alter the biological community.

The energy of flowing water is another important consideration. Capping projects are easier to design in low energy environments (e.g., protected harbors, slow-flowing rivers, or micro-tidal estuarine systems). In open water, deeper sites are generally less influenced by wind or wave generated currents and less prone to erosion than shallow, near-shore environments. However, armoring techniques or selection of erosion-resistant capping materials can make capping technically feasible in some high energy environments. In a riverine environment, the placement of a cap generally reduces depth and restricts flow and may alter the sediment and flood-carrying capacity of the channel.

DRAFT

Effectiveness - Capping would not reduce the volume or toxicity of contaminated sediment, but could potentially reduce exposure by direct contact and the migration of contaminated sediment. Capping is generally more well-suited for deep-water and/or slow velocity environments. The long term reliability of the cap is questionable because of the generally shallow water and high-energy environment. Capping materials are not readily available onsite and would likely need to be imported from offsite. Capping would require conventional construction equipment (dump trucks, loaders, etc.) and skilled construction workers to provide and place the capping materials. Placement of cap materials could be detrimental to fish habitat.

Implementability - This alternative is both administratively and technically implementable. Implementation of a capping process option would require a 404 permit from the US Army Corps of Engineers, a Stream Protection Act 124 permit from FWP, a 318 permit (temporary exceedance of turbidity standards)from DEQ, and a storm water general permit for construction activities from DEQ.

Cost - Costs for capping would be considered low to medium compared to other process options. Costs for less invasive process options (institutional controls and MNR) would be less than capping, while costs for removal, treatment, and disposal process options would be greater than for capping.

Screening Summary - Given the constraints imposed by the high energy flow environment of Big Spring Creek, the potential for erosion of cap material, and the potential impacts to important fish habitat, in-situ capping will not be considered as a stand-alone alternative for remediation of Big Spring Creek sediment. It may be necessary to place clean backfill material if dredging or excavation is selected as a remedy; however, this is not considered to be capping by EPA (2005).

3.4.5 Sediment Removal Via Mechanical Dredging

General - Mechanical dredges use a bucket to dislodge, grab, and remove sediment. The fundamental difference between mechanical and hydraulic dredging equipment is how the sediment is removed. Mechanical dredges offer the advantage of removing the sediment at nearly the same solids content and, therefore, volume as the in-situ material. Little additional water is entrained with the sediment as it is removed. Thus, the volumes of contaminated material and process water to be disposed, managed, and/or treated are minimized compared to hydraulic dredging. However, the water that is present in the bucket above the sediment must either be collected, managed, and treated, or be permitted to leak out, which generally leads to higher contaminant losses during dredging.

The mechanical dredges most commonly used in the U.S. for environmental dredging are the following (Palermo et al. 2004):

- *Clamshell:* Wire supported, conventional open clam bucket, circular shaped cutting action;

- *Enclosed bucket:* Wire supported, near watertight or sealed bucket as compared to conventional open clam bucket (recent designs also incorporate a level cut capability as compared to a circular-shaped cut for conventional buckets, for example, the Cable Arm and Boskalis Horizontal Closing Environmental Grab); and

DRAFT

- *Articulated mechanical:* Backhoe designs, clam-type enclosed buckets, hydraulic closing mechanisms, all supported by articulated fixed-arm (e.g., Ham Visor Grab, Bean Horizontal Profiling Grab (HPG), Toa High Density Transport, and the Dry Dredge).

The mechanical dredge types listed above reflect equipment used for environmental dredging and generally are readily available in the U.S (EPA, 2005). The enclosed bucket dredges were designed to address a number of issues often raised relative to remedial dredging including contaminant removal efficiency and minimizing sediment resuspension. However, newly redesigned dredging equipment may not be cost-effective or preferred at every site. For example, in some environments, an enclosed bucket may be most useful for soft sediment but may not close efficiently on debris. A conventional clamshell dredge may have greater leverage and be able to close on or cut debris in some cases; however, material mounded over the top may be resuspended. An articulated mechanical dredge may have an advantage in stiffer sediment since the fixed-arm arrangement can push the bucket into the sediment to the desired cut-level, and not rely on the weight of the bucket for penetration.

<u>Effectiveness</u> - Mechanical dredging does not reduce the volume or toxicity of impacted sediment, but would effectively reduce contaminant mobility at the site by removing the contaminant sources from the stream environment. Adequate control of sedimentation, resuspension of contaminants, and sediment dewatering prior to disposal are crucial to the effectiveness of this process option. The coarse nature of the bed sediment may be problematic for some types of mechanical dredges (i.e., clamshell and enclosed bucket). Articulated mechanical dredges, such as a conventional hydraulic excavator, may prove most effective in the coarse sediment since the water is generally shallow. Screening to remove oversize material that may not be impacted with paint chips may prove effective at reducing the disposal volume. Ancillary activities for processing dredged sediment, including temporary sediment storage, dewatering, separation/sorting, and loadout, would require staging areas adjacent to the stream. Staging areas would be required at sufficient intervals to be near the dredge to allow efficient transport of the dredged material. Staging areas would require access permission and coordination with land owners adjacent to the stream.

<u>Implementability</u> - This alternative is both administratively and technically implementable. The construction steps required are considered standard construction practices. Key project components, such as the availability of personnel, equipment and materials, are present and would help allow the timely implementation and successful execution this process option. Implementation of mechanical dredging would require a 404 permit from the US Army Corps of Engineers, a Stream Protection Act 124 permit from FWP, a 318 permit (temporary exceedance of turbidity standards) from DEQ, and a storm water general permit for construction activities (since the surface disturbance would be greater than one acre) from DEQ.

<u>Cost</u> - Costs to remove PCB-impacted sediment via mechanical dredging would be in the medium range when compared to other process options.

<u>Screening Summary</u> - Mechanical dredging has been retained for further evaluation because it is readily implementable and provides a high degree of effectiveness and permanence at a medium range cost.

DRAFT

3.4.6 Sediment Removal Via Hydraulic Dredging

General - Hydraulic dredges remove and transport sediment in the form of a slurry through the inclusion or addition of high volumes of water at some point in the removal process (Zappi and Hayes 1991). The total volume of material processed may be greatly increased and the solids content of the slurry may be considerably less than that of the in-situ sediment although solids content varies between dredges (U.S. EPA 1994d). The excess water is usually discharged as effluent at the treatment or disposal site and often needs treatment prior to discharge. Hydraulic dredges may be equipped with rotating blades, augers, or high-pressure water jets to loosen the sediment (U.S. EPA 1995b). The hydraulic dredges most commonly used in the U.S. for environmental dredging are the following (Palermo et al. 2004):

- *Cutterhead:* Conventional hydraulic pipeline dredge, with conventional cutterhead;
- *Horizontal auger:* Hydraulic pipeline dredge with horizontal auger dredgehead (e.g., Mudcat);
- *Plain suction:* Hydraulic pipeline dredge using dredgehead design with no cutting action, plain suction (e.g., cutterhead dredge with no cutter basket mounted, Matchbox dredgehead, articulated Slope Cleaner, Scoop-Dredge BRABO, etc.);
- *Pneumatic:* Air operated submersible pump, pipeline transport, either wire supported or fixed-arm supported (e.g., Japanese Oozer, Italian Pneuma, Dutch "d," Japanese Refresher, etc.);
- *Specialty dredgeheads:* Other hydraulic pipeline dredges with specialty dredgeheads or pumping systems (e.g., Boskalis Environmental Disc Cutter, Slope Cleaner, Clean Sweep, Water Refresher, Clean Up, Swan 21 Systems, etc.); and
- *Diver assisted:* Hand-held hydraulic suction with pipeline transport.

Some of the hydraulic dredges included above have been specifically developed to reduce resuspension during the removal process; however, there may be tradeoffs in terms of production rate and ability to handle debris with many of these modifications. A plain suction dredge or a suction dredge with a high-pressure water jet, as the Sand Wand used in the pilot test (Section 1.2.7), is probably most suitable for the conditions at Big Spring Creek because of the ability to limit resuspension of sediment and the ability to remove thin layers.

Effectiveness - Hydraulic dredging does not reduce the volume or toxicity of impacted sediment, but would effectively reduce contaminant mobility at the site by removing the contaminant sources from the stream environment. Adequate control of sedimentation, resuspension of contaminants, and sediment dewatering prior to disposal are crucial to the overall effectiveness of this process option. A pilot test of a small suction dredge was completed in the fall of 2006 (Olympus, 2008a and FWP, 2007). The dredge had a suction head equipped with a one-inch diameter water jet that pumps at a rate of approximately 90 gallons per minute, and a three-inch diameter suction hose to remove the fine materials dislodged by the action of the water jet. The suction hose operates at a flow rate of approximately 340 gallons per minute. The suction dredge removed approximately 91 percent of the PCB-impacted paint chips from the upper 5 to 7 inches of sediment based on limited testing of the dredged and adjacent undredged area. The results of the pilot test show that a suction dredging is capable of removing PCB-laden paint chips from the stream environment. Ancillary activities for processing dredged sediment,

DRAFT

including temporary sediment storage, dewatering, separation/sorting, and loadout, would require staging areas adjacent to the stream. Staging areas would be required at sufficient intervals to be near the dredge to allow efficient transport of the dredged material. Staging areas would require access permission and coordination with land owners adjacent to the stream.

Implementability - This alternative is both administratively and technically implementable. Key project components, such as the availability of personnel, equipment and materials, are present and would help allow the timely implementation and successful execution this process option. Implementation of hydraulic dredging would require a 404 permit from the US Army Corps of Engineers, a Stream Protection Act 124 permit from FWP, a 318 permit (temporary exceedance of turbidity standards) from DEQ, and a storm water general permit for construction activities (since the surface disturbance would be greater than one acre) from DEQ. Procedures for controlling sedimentation during dredging, processing and handling the dredged sediment, and sediment dewatering must also be developed.

Cost - Costs to remove PCB-impacted sediment via hydraulic dredging would be in the medium range when compared to other process options.

Screening Summary - Hydraulic dredging has been retained for further evaluation because it is readily implementable and provides a high degree of effectiveness and permanence at a medium range cost.

3.4.7 Dry Excavation

General - Excavation of contaminated sediment generally involves isolating the contaminated sediment from the overlying water body by pumping or diverting water from the area, and managing any continuing inflow followed by sediment excavation using conventional dry land equipment. However, excavation may be possible without water diversion in some areas such as wetlands during dry seasons or while the sediment and water are frozen during the winter. Typically, excavation is performed in streams, shallow rivers and ponds, or near shore areas.

Prior to pumping out the water, the area can be isolated using one or more of the following technologies:

- Sheet piling;
- Earthen dams;
- Cofferdams;
- Geotubes, inflatable dams;
- Rerouting the water body using temporary dams, channels, or pipes; or
- Permanent relocation of the water body.

Sediment isolation using sheet piling commonly involves driving interlocking metal plates (i.e., sheet piles) into the subsurface, and thereby either blocking off designated areas or splitting a stream down the center. If a stream is split down its center, then one side of the stream may be excavated in the dry, after pumping out the trapped water. When the excavation of the first side of the stream is completed, water may be diverted back to the excavated side and sediment on the other side may be excavated. Sheet piling may not be feasible where bedrock or hard strata are present at or near the bottom surface. Potential hydraulic impacts of the diverted flow should be considered where sheet piling is used to isolate a dredging or excavation action.

DRAFT

Such diversion in most cases will increase natural flow velocity, which may scour sediment outside the diversion wall. If the sediment is also contaminated, as is likely to be the case, the increased dispersion of the sediment should be considered in design choices. Temporarily rerouting a water body with dams is sometimes done for small streams or ponds. This includes the use of temporary dams to divert the water flow allowing excavation of now “dry” contaminated sediment. The ability and cost to provide hydraulic isolation of the contaminated area during remediation is a major factor in selecting the appropriate removal technology.

Once isolated, standing water within the excavation area will need to be removed. Although surface water flows are eliminated, ground water may infiltrate the confined area. The ground water can be collected in sumps or dewatering wells. After collection, the ground water should be characterized, managed, treated (if necessary), and discharged to an appropriate receiving water body. Management of water within the confined area is another important logistical and cost factor that can influence the decision of wet versus dry removal techniques.

Isolation and dewatering of the area is normally followed by excavation using conventional earthmoving equipment such as a backhoe or dragline. Where sediment is soft, support of the excavation equipment in the dewatered area can be problematic because underlying materials may not have the strength to support equipment weight. This also may reduce excavation depth precision. Both factors should be accounted for in design. When the excavation activities are complete, temporary dam(s) or sheet piling(s) are removed, and the water body is restored to its original hydraulic condition.

Another less common type of excavation project involves permanent relocation of a water body This, for example, was accomplished at the Triana/Tennessee River Superfund Site in Alabama and is being implemented at the Moss-American Superfund site in Wisconsin. The initial phases of such a project may be similar to excavation projects that temporarily reroute a water body. However, in a permanent stream relocation project, a replacement stream normally is constructed and then the original water body is excavated or capped and converted into an upland area. To the extent the original water body is covered over, direct exposure to residual contamination is generally eliminated.

Excavation may also include excavation of sediment in areas that experience occasional dry conditions, such as intermittent streams and wetlands. These types of projects generally are logistically similar to upland construction projects and frequently use conventional earthmoving equipment.

<u>Effectiveness</u> - Dry excavation does not reduce the volume or toxicity of impacted sediment, but would effectively reduce contaminant mobility at the site by removing the contaminant sources from the stream environment. Dry excavation would require that portions of the stream be isolated and pumped dry prior to excavation. Dry excavation provides an effective means of controlling sedimentation during sediment removal activities and reduces the water content compared to dredging options. The absence of water in the excavation provides the advantage of greater visibility for equipment operators and reduces the likelihood of suspension and migration of contaminants during excavation. Ancillary activities for processing excavated sediment, including temporary sediment storage, dewatering, separation/sorting, and loadout, would require staging areas adjacent to the stream. Staging areas would be required at sufficient intervals to be near the dredge to allow efficient transport of the excavated material. Staging areas would require access permission and coordination with land owners adjacent to the stream.

DRAFT

Implementability - This alternative is both administratively and technically implementable. Key project components, such as the availability of personnel, equipment and materials, are present and would help allow the timely implementation and successful execution of this process option. Implementation of dry excavation would require a 404 permit from the US Army Corps of Engineers, a Stream Protection Act 124 permit from FWP, a 318 permit (temporary exceedance of turbidity standards) from DEQ, and a storm water general permit for construction activities (since the surface disturbance would be greater than one acre) from DEQ. Procedures for controlling sedimentation during excavation, processing and handling of sediment, and sediment dewatering must also be developed and implemented.

Cost - Costs to remove PCB-impacted sediment via dry excavation would be in the medium range when compared to other process options.

Screening Summary - Dry excavation has been retained for further evaluation because it is readily implementable and provides a high degree of effectiveness and permanence at a medium range cost.

3.4.8 Chemical Treatment Via Ex-Situ Dehalogenation

General - With Ex-Situ Dehalogenation, contaminated soil or sediment is screened, processed with a crusher and pug mill, and mixed with reagents. The mixture is heated in a reactor. The dehalogenation process is achieved by either the replacement of the halogen molecules or the decomposition and partial volatilization of the contaminants. There are two primary methods for dehalogenation: 1) base-catalyzed decomposition (BCD), and 2) Glycolate/Alkaline Polyethylene Glycol (APEG).

The BCD process was developed by EPA's Risk Reduction Engineering Laboratory (RREL), in cooperation with the Naval Facilities Engineering Services Center (NFESC) to remediate soils and sediments contaminated with chlorinated organic compounds, especially PCBs, dioxins, and furans. Contaminated soil is screened, processed with a crusher and pug mill, and mixed with sodium bicarbonate. The mixture is heated to above 330 °C (630°F) in a reactor to partially decompose and volatilize the contaminants. The volatilized contaminants are captured, condensed, and treated separately.

Glycolate is a full-scale technology in which an alkaline polyethylene glycol reagent is used. Potassium polyethylene glycol (KPEG) is the most common APEG reagent. Contaminated soils and the reagent are mixed and heated in a treatment vessel. In the APEG process, the reaction causes the polyethylene glycol to replace halogen molecules and render the compound nonhazardous or less toxic. The reagent (APEG) dehalogenates the pollutant to form a glycol ether and/or a hydroxylated compound and an alkali metal salt, which are water-soluble byproducts. Dehalogenation (APEG/KPEG) is generally considered a stand-alone technology; however, it can be used in combination with other technologies. Treatment of the wastewater generated by the process may include chemical oxidation, biodegradation, carbon adsorption, or precipitation.

Treatment of PCBs by Ex-Situ Dehalogenation is typically used as part of a treatment train to reduce high PCB concentrations to levels where residual soil or sediment can be disposed of at a landfill or other confined disposal facility. As described in Section 3.4.11, sediment with a PCB concentration greater than 50 mg/kg cannot be disposed of at a solid waste landfill and must be disposed of at a TSCA landfill.

DRAFT

Effectiveness - This process option would reduce contaminant toxicity at the site by reducing contaminant levels. The contaminant volume may be reduced somewhat as oversized material is screened out. The contaminant mobility would be reduced by removal of the contaminated sediment soil from the exposure to the environment and by treatment and post-treatment management of the materials. According to FRTR (2008), PCB concentrations as high as 45,000 mg/kg have been treated to less than 2 mg/kg; however, byproducts of dehalogenation, including contaminated air, water, and sludge, may require further treatment and handling. Remediation data for PCBs is typically based on PCBs in an oil form rather than being bound in a paint chip matrix. It is not known whether this technology will perform well for the form of PCBs associated with the site.

The effectiveness of the dehalogenation process may be reduced by the high moisture content of the sediment. The high organic content and clay fraction of the some sediment may also reduce the effectiveness of the process. Treatability tests should be conducted to identify parameters such as water, alkaline metals, and humus content in the soils; the presence of multiple phases; and total organic halides that could affect processing time and cost. Handling and disposal of the soil after treatment by dehalogenation will depend on the contaminant concentrations after treatment; however, it is likely that the sediment will still require off-site disposal.

Implementability - The target contaminant groups for dehalogenation treatment are halogenated SVOCs (including PCBs) and pesticides. APEG dehalogenation is one of the few processes available other than incineration that has been successfully field tested in treating PCBs. The technology is amenable to small-scale applications. Dehalogenation is normally a short- to medium-term process. The contaminant is partially decomposed rather than being transferred to another medium. The use of dehalogenation is both technically and administratively feasible. The equipment required is considered standard (FRTR, 2008).

Cost - The cost for full-scale dehalogenation is typically in the range of $200 to $500 per ton, not including excavation, refilling, residue disposal, or analytical costs (FRTR, 2008). Factors such as high clay or moisture content may raise the treatment cost slightly. The cost of dehalogenation is considered high compared to other alternatives. Residual sediment would probably still require disposal at a landfill after treatment via HTTD.

Screening Summary - This alternative has not been retained for detailed analysis because of the high cost. The PCB concentrations in stream sediment are low enough that treatment would likely not be required prior to disposal. A similar degree of relative effectiveness can be obtained by other alternatives being evaluated at significantly reduced costs.

3.4.9 Chemical Treatment Via Ex-Situ Thermal Desorption

General - Thermal Desorption is a physical separation process and is not designed to destroy organics. Wastes are heated to volatilize water and organic contaminants. A carrier gas or vacuum system transports volatilized water and organics to the gas treatment system. The bed temperatures and residence times designed into these systems will volatilize selected contaminants but will typically not oxidize them.

Based on the operating temperature of the desorber, thermal desorption processes can be categorized into two groups: high temperature thermal desorption (HTTD) and low temperature thermal desorption (LTTD). The target contaminants for HTTD are SVOCs, PAHs, PCBs, and

DRAFT

pesticides. The target contaminant groups for LTTD systems are nonhalogenated VOCs and fuels. It is not known whether HTTD will be effective at removing PCBs bound in a paint chip matrix.

Effectiveness - HTTD is a full-scale technology in which wastes are heated to 320 to 560 °C (600 to 1,000 °F). HTTD is frequently used in combination with incineration, solidification/stabilization, or dechlorination, depending upon site-specific conditions. The technology has proven it can produce a final contaminant concentration level below 5 mg/kg for the target contaminants identified; however, remediation data for PCBs is typically based on PCBs in an oil form rather than being bound in a paint chip matrix. It is not known whether this technology will perform well for the form of PCBs associated with the site.

There are specific particle size and materials handling requirements that can impact applicability or cost at specific sites. Dewatering may be necessary to achieve acceptable soil moisture content levels. Highly abrasive feed potentially can damage the processor unit. Clay and silty soils and high humic content soils increase reaction time as a result of binding of contaminants. In addition to identifying soil contaminants and their concentrations, information necessary for engineering thermal systems to specific applications include soil moisture content and classification, determination of boiling points for various compounds to be removed, and treatability tests to determine the efficiency of thermal desorption for removing various contaminants at various temperatures and residence times. A sieve analysis is needed to determine the dust loading in the system to properly design and size the air pollution control equipment.

Implementability - The target contaminants for HTTD are SVOCs, PAHs, PCBs, and pesticides; however, VOCs and fuels also may be treated, but treatment may be less cost-effective. The process is applicable for the separation of organics from refinery wastes, coal tar wastes, wood-treating wastes, creosote-contaminated soils, hydrocarbon-contaminated soils, mixed (radioactive and hazardous) wastes, synthetic rubber processing waste, pesticides and paint wastes. The use of High Temperature Thermal Desorption is both technically and administratively feasible. The equipment required is considered standard (FRTR, 2008).

Cost - The cost for full-scale dehalogenation is estimated to be in a range of $101 to 232 per cubic yard, not including excavation, refilling, residue disposal, or analytical costs, based on treatment of SVOCs (FRTR, 2008). The quantity of material treated (economy of scale) and high moisture content (increased fuel) are key cost drivers. The cost of HTTD is considered medium to high compared to other alternatives. Residual sediment would still require disposal at a landfill after treatment via HTTD.

Screening Summary - HTTD has not been retained for detailed analysis because of the high cost. The PCB concentrations are low enough that treatment would likely not be required prior to disposal. A similar degree of relative effectiveness can be obtained by other alternatives being evaluated at significantly reduced costs.

3.4.10 Off-Site Disposal at a Solid Waste Landfill

General - Existing commercial, municipal, or hazardous waste landfills are the most widely used option for disposal of dredged or excavated sediment and pretreatment/treatment residuals from environmental dredging and excavation (EPA, 2005). Landfills also are sometimes constructed onsite for a specific dredging or excavation project. Landfills can be categorized by the types of

DRAFT

wastes they accept and the laws regulating their operation. Most solid waste landfills accept all types of waste (including hazardous substances) not regulated as Resource Conservation and Recovery Act (RCRA) hazardous waste or Toxic Substances Control Act (TSCA) toxic materials (EPA, 2005). Due to typical restrictions on liquids in landfills, most sediment should be dewatered and/or stabilized/solidified before disposal in a landfill. Temporary placement in a confined disposal facility (CDF) or pretreatment using mechanical equipment may therefore be necessary (Palermo, 1995).

<u>Effectiveness</u> - Disposal of impacted sediment at a solid waste landfill, when coupled with an effective removal process option (i.e., dredging or excavation), would effectively reduce contaminant mobility at the site by removing the contaminant sources to a secure location. Consequently, the site problems are expected to be permanently corrected. Contaminant toxicity and volume would not be reduced, but would be permanently transferred to a different physical location. Removal of wastes to a Class II MSW landfill facility provides long-term monitoring and control programs to ensure continued effectiveness. However, short-term risks of exposure to the contaminated material may occur during transport to the disposal facility. Sediment disposal at a solid waste landfill may be usable as landfill cover, which is a beneficial use; however, this may not be possible if the sediment is too fine-grained and would constitute a wind-blown dust problem.

<u>Implementability</u> - This alternative is technically feasible. The construction steps required (excavation and loadout) are considered standard construction practices. Key project components, such as the availability of personnel, equipment and materials, and sufficient landfill capacity, are present and would help allow the timely implementation and successful execution of this process option. This alternative is also administratively feasible because the PCB concentrations are, with the exception of one sample (out of 599 samples), below the threshold requiring disposal at a TSCA facility.

<u>Cost</u> - Transportation and disposal costs associated with solid waste landfill disposal are expected to be in the range of $30 to $50 per ton, not including excavation, backfilling, or dewatering. This cost is in the medium range when compared with other treatment and disposal process options.

<u>Screening Summary</u> - This process option has been retained for further evaluation because it provides a high degree of effectiveness and permanence at a relatively low cost when compared to other treatment and disposal process options.

3.4.11 Off-Site Disposal at a TSCA Landfill

<u>General</u> - The primary difference between disposal at a solid waste landfill (Section 3.4.10) and at a TSCA landfill is the types of waste that are allowed for disposal. There is a regulatory threshold for disposal of PCB remediation waste of 50 parts per million (ppm) or mg/kg (Title 40 CFR Part 761.3). A solid waste landfill cannot accept PCB remediation waste with a PCB concentration that is greater than 50 mg/kg, while a TSCA landfill can accept these wastes.

Of the 452 stream sediment samples collected by Herrera (2006) and the 147 stream sediment samples collected during the Phase 1 remedial investigation (Olympus, 2008b), only one sample contained a PCB concentration that exceeded the threshold of 50 mg/kg. This sample contained a PCB concentration of 260 mg/kg and is thought to have been primarily paint rather than sediment (Herrera, 2006). The second highest PCB concentration observed in the stream

DRAFT

sediment samples was 25 mg/kg. PCB concentrations in paint samples that were collected from the hatcheries were observed at concentrations ranging from less than analytical detection limits up to 86,500 mg/kg. Therefore, it is conceivable that a concentration of 260 mg/kg could be observed in stream sediment; however, based on the other 598 stream sediment analyses, this concentration appears anomalous. Since this one sample would have a very limited sphere of influence and would have a small effect compared to the volume of material that will potentially require disposal, disposal of stream sediment at a TSCA landfill is likely not warranted.

Effectiveness - Disposal at a TSCA facility, when coupled with an effective removal process option (i.e., dredging or excavation), would effectively reduce contaminant mobility at the site by removing the contaminant sources to a secure location. Consequently, the site problems are expected to be permanently corrected. Contaminant toxicity and volume would not be reduced, but would be permanently transferred to a different physical location. Disposal at a TSCA-permitted facility establishes long-term monitoring and control programs to enhance continued effectiveness. Short-term risks of exposure to the contaminated material would occur during transport to the disposal facility. However, the PCB concentrations in the waste materials are generally less than the TSCA threshold of 50 mg/kg.

Implementability - This alternative is both technically and administratively feasible. The construction steps required (excavation and loadout) are considered standard construction practices. Key project components, such as the availability of equipment, materials, and a TSCA facility with adequate capacity, are present and would allow for the timely implementation and successful execution of this option. However, as described above, the waste generally does not exceed the criteria that requires disposal at a TSCA facility. The nearest TSCA facilities are located in Idaho and Utah.

Cost - The cost for transportation and disposal at a TSCA landfill is estimated to be at least $200 per ton, not including excavation, backfilling, or dewatering. The cost of disposal at a TSCA landfill is considered high compared to other process options, although it is less than dehalogenation and thermal desorption.

Screening Summary - This process option has not been retained for further evaluation because PCB concentrations in stream sediment do not warrant disposal at a TSCA facility and because of high costs. A similar degree of relative effectiveness can be obtained by other process options being evaluated at reduced costs. Based on the PCB concentrations in stream sediment, the waste material should be eligible for disposal in a solid waste landfill at a substantially lower cost.

DRAFT

4.0 Development and Screening of Remediation Alternatives

Remediation alternatives were initially identified and evaluated in the IASD (Olympus, 2008b). This section summarizes the potential remediation alternatives from the general response actions, remediation technologies, and associated process options that passed the screening effort presented in Section 3.4. Retained process options included no action, mechanical dredging, hydraulic dredging, dry excavation, and off-site disposal at a solid waste landfill.

It should be noted that MNR, institutional controls, and in-situ capping are not considered stand-alone remediation technologies, but may be effective in conjunction with removal and disposal process options. Similarly, institutional controls, such as fish consumption advisories and catch and release only fishing regulations (both currently in effect), are not an effective stand-alone remediation process option (see Section 3.4.3); however, these institutional controls are likely to remain in effect for a period following remediation until PCB concentrations in fish tissue are reduced to safe levels for consumption.

These retained general response actions, remediation technologies, and process options have been combined to form the following remediation alternatives. Alternative remedies developed for the Site range from a no action alternative (required by the NCP) to a total removal alternative. An important consideration in selection of alternatives is a comparison of tradeoffs between reducing PCB concentrations in stream sediment, reducing PCB concentrations in fish tissue, and the corresponding degree of habit destruction. An alternative that provides for total removal of PCB-impacted stream sediment would result in lower PCB concentrations in both stream sediment and fish tissue; however, this type of alternative would also completely destroy the existing habitat and fish resources. Conversely, an alternative that removes only a portion of PCB-impacted stream sediment would be less effective in reducing PCB concentrations in stream sediment than complete removal and would also be less effective in reducing PCB concentrations in fish tissue. Although a less invasive alternative, such as partial removal of PCB-impacted stream sediment, would not be as effective at lowering PCB concentrations, it would preserve more existing habitat and fish resources.

Because of the tradeoff between the degree of PCB removal and habit destruction, a wide range of remediation alternatives are proposed for detailed analyses. It should be noted that not all of these alternatives will necessarily meet the threshold criteria (overall protection of human health and the environment and compliance with ARARs) described in Section 5.0; however, each will be evaluated in the detailed screening of alternatives. Alternatives that do not meet the threshold criteria will be screened out in the detailed analysis. The alternatives proposed for detailed analysis in the FS are:

Alternative 1 No Action

Alternative 2 Partial Removal of PCB-Impacted Stream Sediment Via Mechanical Dredging with Disposal at a Solid Waste Landfill

Alternative 3 Partial Removal of PCB-Impacted Stream Sediment Via Hydraulic Dredge with Disposal at a Solid Waste Landfill

Alternative 4 Partial Removal of PCB-Impacted Stream Sediment Via Dry Excavation with Disposal at a Solid Waste Landfill

DRAFT

Alternative 5 Complete Removal of PCB-Impacted Stream Sediment Via Mechanical Dredging with Disposal at a Solid Waste Landfill

Alternative 6 Complete Removal of PCB-Impacted Stream Sediment Via Hydraulic Dredging with Disposal at a Solid Waste Landfill

Alternative 7 Complete Removal of PCB-Impacted Stream Sediment Via Dry Excavation with Disposal at a Solid Waste Landfill

It is possible that a combination of remediation alternatives may be deemed the most feasible site remedy. Mechanical dredging or dry excavation may be more suitable in reaches or subreaches where the PCB impacts have been observed in the deeper depth intervals, while suction dredging may be more feasible for surficial impacts. Therefore, a proposed remedy could be a combination of two or more of the proposed alternatives.

Often times alternatives are further screened at this point using the criteria of effectiveness, implementability, and cost to remove alternatives that may not be feasible prior to recommending alternatives to undergo detailed analyses. Given the limited number of process options that have been deemed feasible for this project (removal and disposal) and the similarity of removal options (dredging and excavation), each of the seven proposed remediation alternatives have similar effectiveness and implementability. Therefore, all seven alternatives proposed above underwent the detailed analyses in the FS and no further screening is presented here. Detailed cost estimates were prepared as part of the detailed analysis of alternatives in Section 5.0.

DRAFT

5.0 Detailed Analysis of Alternatives

The FS includes a detailed analysis of remediation alternatives according to EPA guidance (EPA, 1988). The purpose of the detailed analysis is to provide a more in depth evaluation of the alternatives that were retained after the preliminary evaluation of remediation alternatives. Only those remediation alternatives which were retained after the preliminary evaluations (see Section 3.4 and 4.0) have been included in the detailed analysis. Alternatives that are evaluated in detail are consistent with contaminated sediment guidance from EPA (EPA, 2005).

A summary of the detailed alternative screening criteria is presented in Table 15. As required by CERCLA and the NCP, remediation alternatives that were retained after the preliminary evaluation have to be evaluated individually against the following criteria:

- overall protection of human health and the environment;
- compliance with ARARs;
- long-term effectiveness and permanence;
- reduction of toxicity, mobility, or volume through treatment;
- short-term effectiveness;
- implementability; and
- cost.

Supporting agency acceptance and community acceptance are additional criteria that will be addressed after EPA, DEQ, the Big Spring Creek PCB Advisory Committee, and the public have a chance to review the evaluations presented. The analysis criteria have been used to address the CERCLA requirements and considerations with EPA guidance (EPA, 1988), as well as additional technical and policy considerations. These analysis criteria serve as the basis for conducting the detailed analysis and subsequently selecting the preferred remediation alternative. The criteria listed above are categorized into three groups, each with distinct functions in selecting the preferred alternative. These groups include:

- Threshold Criteria - overall protection of human health and the environment and compliance with ARARs;
- Primary Balancing Criteria - long-term effectiveness and permanence; reduction of toxicity, mobility, or volume through treatment; short-term effectiveness; implementability; and cost; and
- Modifying Criteria - supporting agency and community acceptance.

Overall protection of human health and the environment and compliance with applicable or relevant and appropriate requirements are threshold criteria that must be satisfied for an alternative to be eligible for selection. Long-term effectiveness and permanence; reduction of toxicity, mobility, or volume; short-term effectiveness; implementability; and cost are the primary balancing factors used to weigh major trade-offs between alternative waste management strategies. Supporting agency and community acceptance are modifying considerations that are formally considered after public comment is received on the proposed plan and the RI/FS report (Federal Register, No. 245, 51394-50509, December 1988). Each of these criteria is briefly described in the following paragraphs.

Overall protection of human health and the environment is one of the two threshold criteria that must be met by each alternative. This evaluation criterion provides an assessment of the

DRAFT

extent to which a given alternative is protective of human health and the environment. As part of the determination of protectiveness, the evaluation describes how risks through each pathway would be eliminated, reduced, or controlled through treatment, engineering, or institutional controls.

Compliance with ARARs is the second threshold criteria that must be met by each alternative. The compliance with ARARs criteria assesses how each alternative complies with applicable or relevant and appropriate standards, criteria, advisories, or other guidelines. Waivers will be identified, if necessary. The following factors were addressed for each alternative during the detailed analysis of ARARs:

- compliance with chemical-specific ARARs;
- compliance with action-specific ARARs;
- compliance with location-specific ARARs; and
- compliance with appropriate criteria, advisories, and guidelines.

Long-term effectiveness and permanence evaluates the alternative's effectiveness in protecting human health and the environment after response objectives have been met. The following components of the criteria are addressed for each alternative:

- magnitude of remaining risk;
- adequacy of controls; and
- reliability of controls.

The **reduction of toxicity, mobility, or volume** assessment evaluates anticipated performance of the specific treatment technologies. This evaluation focuses on the following specific factors for a particular remediation alternative:

- the treatment process, the remedies they would employ, and the materials they would treat;
- the amount of hazardous materials that would be destroyed or treated, including how principal threat(s) would be addressed;
- the degree of expected reduction in toxicity, mobility, or volume measured as a percentage of reduction (or order of magnitude);
- degree to which the treatment would be irreversible; and
- the type and quantity of treatment residuals that would remain following treatment.

Short-term effectiveness evaluates an alternative's effectiveness in protecting human health and the environment during the construction and implementation period until the response objectives are met. Factors that were considered under this criteria include:

- protection of the surrounding community during remedial actions;
- protection of on-site workers during remedial actions;
- protection from environmental impacts; and
- time until removal response objectives are achieved.

Implementability evaluates the technical and administrative feasibility of alternatives and the availability of required resources. Analysis of this criterion included the following factors and subfactors:

DRAFT

Technical Feasibility

- construction and operation;
- reliability of technology;
- ease of undertaking additional remedial action; and
- monitoring considerations.

Administrative Feasibility

- RCRA and/or TSCA disposal restrictions;
- institutional controls; and
- permitting requirements.

Availability of Services and Materials

- adequate off-site treatment, storage capacity, and disposal service;
- necessary equipment and specialists and provisions to ensure any necessary additional resources;
- timing of the availability of technologies under consideration; and
- services and materials.

The **cost** assessment evaluates the capital and operation and maintenance (O&M) costs of each alternative. A present-worth analysis based on a 7-percent inflation rate and a maximum design life of 30 years were used to compare alternatives. Cost screening consists of developing conservative, order-of-magnitude cost estimates based on similar sets of site-specific assumptions. Cost estimates for each alternative considered the following factors:

Capital Costs

- construction costs;
- equipment costs;
- land and site development costs;
- disposal costs;
- engineering design;
- legal fees, license, and permit costs;
- startup and troubleshooting costs; and
- contingency allowances.

Annual Costs

- operating labor;
- maintenance materials and labor;
- auxiliary materials and energy;
- disposal residues;
- purchased services (i.e., sampling costs, laboratory fees, professional fees);
- administrative costs;
- insurance, taxes, and licensing;
- maintenance reserve and contingency funds;
- rehabilitation costs; and
- periodic site reviews.

DRAFT

Supporting agency acceptance will evaluate the technical and administrative issues and concerns the supporting agency may have regarding each of the alternatives. Because EPA has taken the lead role in the regulatory process, this criterion will address DEQ's views on the evaluation and analysis presented here. Supporting agency acceptance will also focus on legal issues and compliance with state statutes and regulations. **Community acceptance** will incorporate public concerns into the analyses of the alternatives.

The final step of this process is to conduct a comparative analysis of the alternatives. The analysis will include a discussion of the alternative's relative strengths and weaknesses with respect to each of the criteria and how reasonable key uncertainties could change expectations of their relative performance.

Once completed, this evaluation will be used to select the preferred alternative(s). The selection of the preferred alternative(s) will be documented in an Action Memorandum or Record of Decision. Public meeting(s) will be conducted to present the alternatives and significant oral and written comments will be addressed in writing.

5.1 Removal Scenarios

Analysis of sediment samples collected during the RI (Olympus, 2009) showed that PCBs were detected in stream sediment from as deep as 30 to 36 inches. PCBs were detected in the 24 to 30 inch depth interval at concentrations below the project screening level of 189 µg/kg in two samples (25 and 93 µg/kg) and one sample had a concentration that was below the detection limit that was estimated at 17 µg/kg. PCBs were detected in the 30 to 36 inch depth interval at concentrations below the screening level in two samples (30 and 43 µg/kg) and one sample had a concentration that was below the detection limit that was estimated at 9.5 µg/kg.

The fish tissue/sediment relationship developed by FWP (Figure 18) shows that PCB concentrations would need to be near zero to allow unlimited consumption of fish. Therefore, complete removal has been defined as removal of sediment to a removal depth of 36 inches, which includes all PCBs detected in the Phase 1 and Herrera RI sampling. The total removal volume under this scenario is approximately 71,000 cubic yards.

One of the stated purposes of the partial removal scenarios is to consider the tradeoff between the degree of sediment removal and the corresponding habitat destruction (Section 4.0). Therefore, two options are considered for each partial removal alternative. Option A (hereafter referred to as Alternative 2A, 3A, or 4A) considers removal of sediment from the upper 6-inch depth interval over the entire length of Site (Subreaches 2A through 4B). Option B (hereafter referred to as Alternative 2B, 3B, or 4B) considers of sediment from the upper 6-inch depth interval from Subreaches 2A, 2B, and 3A. The basis for selecting Subreaches 2A, 2B, and 3A is as follows.

Subreaches 2A and 3A have the highest PCB concentrations in the upper 6 inches as shown on Figure 5 and Figure 6, and based on 95% UCL of mean PCB concentrations in stream sediment (Table 5). PCB concentrations in the upper 6 inches of stream sediment are most closely represented by depth intervals H1 and H2 of the Herrera stream sediment data set. The 95% UCLs of mean PCB concentrations in depth intervals H1 and H2 in Subreaches 2A and 3A range from approximately 5,500 to 90,000 µg/kg and 380 to 12,000 µg/kg, respectively. The 95% UCLs of mean PCB concentrations in depth intervals H1 and H2 in Subreach 2B range from approximately 130 to 380 µg/kg, which is much less than the concentrations in Subreaches

DRAFT

2A and 3A. The 95% UCLs of mean PCB concentrations in depth intervals H1 and H2 in Subreaches 3B, 4A, and 4B range from approximately 100 to 460 µg/kg, which is similar to the concentrations in Subreach 2B. Based on these data, removal of sediment in the upper 6 inches of Subreach 2A and 3A would remove the most highly-contaminated portions of the Site. Sediment from Subreach 2B would also be removed to prevent PCBs from migrating from Subreach 2B into the remediated Subreach 3A.

Based on the Phase 2 particle size sampling (Olympus, 2009), paint chips were only observed in the sieve fractions that were less than 6.3 mm (1/4-inch). Therefore, sediment removal efforts would likely concentrate on the 1/4-inch minus size fraction. The particle size sampling compared the mass of paint chips in control samples before and after sieving. Comparison of these samples indicated that paint chips are broken down in size by the sieving action. The particle size samples from the RI indicated approximately 42 percent of sediment by weight is finer than 1/4 inches. This percentage is based a weighted average of the fraction of sediment that is finer than 1/4 inches by area and geomorphic type. It should be noted that the particle size samples were collected to a depth of 6 inches into the streambed and were collected using a 6-inch diameter core sampler. Therefore, the percentage of fines does not consider particle sizes larger than 6 inches.

The volume of sediment in the upper 6-inch layer is 11,830 CY for Option A and 4,780 CY for Option B. The fraction of sediment that is finer than 1/4 inches is estimated at approximately 5,000 and 2,000 CY for Options A and B, respectively. The fraction of sediment that is finer than 1/4 inches is estimated at approximately 30,000 CY for complete removal to a depth of 36 inches.

5.2 Alternatives 1: No Action

The no action alternative means that no remediation is completed at the site to control contaminant migration or to reduce toxicity or volume. This option would require no further remedial investigation or monitoring action at the site. The no action response is generally used as a baseline against which other remediation options can be compared. This alternative has been retained for further evaluation as suggested by the NCP.

5.2.1 Overall Protection of Human Health and the Environment

The no action alternative provides no control of exposure to the contaminated materials and no reduction in risk to human health or the environment. No control measures would be completed on the non-point source waste (PCBs in stream sediment) identified as causing environmental impacts at the site. The no action alternative would not address contaminant migration or exposure of PCBs to fish and other biota. Human health exposure to PCBs from consumption of contaminated fish would not be addressed.

5.2.2 Compliance With ARARs

A comprehensive list of federal and state ARARs is presented in Section 2.0 and Appendix E. ARARs are divided into contaminant-specific, location-specific, and action-specific requirements. Under the no action alternative, no contaminated materials would be treated, removed, or actively managed. Stream sediment would continue to exceed the federal

DRAFT

chemical-specific ARAR-based PRG of 1 mg/kg (1,000 µg/kg) for PCB remediation waste in high occupancy areas (see Section 3.1.2.1); however, it should be noted that the EPA regional administrator may also require cleanup to more stringent levels based on proximity to areas such as residences, wetlands, fisheries, etc. The no action alternative would also not meet the federal action-specific ARARs that address cleanup and disposal of PCB remediation wastes. Allowing disposal or storage of the toxic materials, including PCB contaminated materials, in the 100-year floodplain would violate state location-specific floodplain and solid waste ARARs.

5.2.3 Long-Term Effectiveness and Permanence

The risk to human health and the environment would not be reduced under the no action alternative. No control measures would be completed on the non-point source waste (stream sediment) identified as causing environmental impacts at the site. The no action alternative would not address Site impacts that have been identified nor would it provide controls on contaminant migration or exposure of PCBs to fish and other biota. Human health exposure to PCBs from consumption of contaminated fish would not be addressed.

5.2.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

The no action alternative would provide no reduction in toxicity, mobility, or volume of the contaminated materials.

5.2.5 Short-Term Effectiveness

Short-term effectiveness is not applicable to the no action alternative. The no action alternative, while retained for further evaluation, is used primarily for the purpose of baseline comparisons with other alternatives, since this approach would not achieve the reductions in sediment and fish PCBs levels needed to meet RAOs. The PCB concentrations in both the sediment and fish do not appear to be currently decreasing. Significant reductions in PCBs levels in both rainbow and brown trout were observed in the post-hatchery cleanup period of 2004 to 2006, but fish PCB levels have not decreased in subsequent years. Conceivably, there has not been sufficient time to determine if natural attenuation is occurring. However, because PCBs are so highly persistent in the environment, natural attenuation under a no-action approach does not appear to be a reasonable alternative.

5.2.6 Implementability

Technical and administrative feasibility evaluation criteria do not apply to this alternative.

5.2.7 Cost

No capital or operating costs would be incurred under this alternative. Monitoring costs have been estimated at $13,000 per year for continued annual monitoring of PCB concentrations in fish and sediment. The total present worth cost for no action, including 30 years of annual inspections at a cost of $13,000 per year, is estimated at $177,449.

DRAFT

5.3 Alternative 2: Partial Removal of PCB-Impacted Stream Sediment Via Mechanical Dredging with Disposal at a Solid Waste Landfill

The remediation strategy for Alternative 2 involves partial removal of PCB-impacted stream sediment via mechanical dredging. Sediment would be dredged from the streambed using mechanical equipment such as a hydraulic excavator. Mechanical dredging often employs the use of a barge to support excavating equipment. Given the relatively small size of Big Spring Creek and the shallow nature of the stream, a barge would not be practical and the dredging work would be completed from the stream banks or with equipment placed in the stream. The dredged material would be loaded onto haul trucks and transported to a temporary staging and containment area for dewatering. The sediment would be screened to remove oversized material that is not likely to be contaminated. The segregated oversized sediment would be returned to the creek. After screening and dewatering, the remaining sediment would be transported via truck to a permitted Class II municipal solid waste landfill for disposal. The mechanical dredging would destroy the stream habitat so extensive stream restoration construction would be implemented.

Two partial removal scenarios are considered under Alternative 2. Alternative 2A considers the removal of sediment from the upper 6 inches from Subreaches 2A through 4B. Alternative 2B considers the removal of the upper 6 inches of sediment from Subreaches 2A, 2B, and 3A. The rationale for these removal scenarios is presented in Section 5.1. Under Alternative 2B, Subreaches 3B, 4A, and 4B would be monitored according to MNR procedures since remediation would not occur in these areas.

Partial removal would involve sediment being mechanically dredged from the stream bed to a depth of approximately 6 inches using conventional equipment such as a hydraulic excavator in the presence of flowing water. The 6-inch dredging depth is likely to be variable and would be controlled by the size of the larger particles. For example, if the dominant particle size in a given area of the stream is 1 foot, dredging to a depth of only 6-inches is nearly impossible. The dredged material would be loaded onto haul trucks and transported to temporary staging and containment areas for dewatering and processing. The sediment would be screened to remove oversized material (>1/4-inch) that is not likely to be contaminated. The segregated oversized sediment would be returned to the creek. After screening and dewatering, the fine sediment would be transported via truck to a permitted Class II municipal solid waste landfill for disposal. Water collected in the dewatering process would be treated to remove turbidity and PCBs in suspended sediment and discharged into Big Spring Creek.

5.3.1 Overall Protection of Human Health and the Environment

As shown in the human health risk assessments (CDM, 2005, 2008, and 2009), the only significant risk to human health is the consumption of PCB-impacted fish. Risks to human health from exposure via direct contact or ingestion of stream sediment and direct contact or ingestion of stream water were not significant.

The implementation of this alternative would provide a means of reducing the risk to both human health and the environment. Partial removal of PCB-impacted sediment, particularly removal of sediment from areas with the highest concentration of PCBs, would reduce the degree of exposure to both aquatic organisms and terrestrial organisms that feed on aquatic organisms. The risk to human health from consumption of PCB-impacted fish would also be reduced accordingly. However, partial removal would leave some PCB-impacted sediment in

DRAFT

place so the exposure pathway would be reduced, but not eliminated. Therefore, exposure of aquatic organisms to PCBs, while reduced, would still exist. Similarly, the exposure of terrestrial organisms that feed on aquatic organisms would be reduced compared to the no action alternative, but would still exist. Human exposure to PCBs from consumption of fish would be reduced under this alternative, but would still exist. Institutional controls, such as fish consumption advisories and catch and release only fishing regulations, would remain in effect at the Site until it is demonstrated that PCBs in fish tissue are at concentrations that are safe for human consumption.

<u>Alternative 2A</u>

The degree of risk reduction is difficult to quantify because of the high variability of the PCBs in stream sediment data, the variability in the fish tissue/stream sediment relationship, and in estimating the post-dredging residual PCB in sediment concentrations. To estimate the degree of risk reduction under Alternative 2A, assumptions have been made about post-remediation residual PCB concentrations, and mean PCB concentrations and 95% UCLs of mean PCB concentrations have been calculated for these conditions and compared to the existing (pre-dredging) mean and 95% UCL to evaluate risk reduction. The 95% UCLs were calculated using EPA's ProUCL statistical software package (EPA, 2007a and 2007b). The pre-dredging mean PCB concentrations are shown in Table 16, and range from 4,785 µg/kg in Subreach 2A to 52.56 in Subreach 4A. The pre-dredging 95% UCLs of mean PCB concentrations are shown in Table 16, and range from 6,761 µg/kg in Subreach 2A to 106.9 µg/kg in Subreach 4A. ProUCL calculations are presented in Appendix G.

Three conditions have been evaluated for post-dredging PCB concentrations in stream sediment (0, 69, and 100 µg/kg in order to test the sensitivity of the model to effectiveness of PCB removal). The estimated residual PCB concentrations for the first condition were based on data from the suction dredge pilot test (Section 1.2.7). The quantity of paint chips found in five post-dredging core samples was an average 0.017% (i.e., 0.00017 mg paint per mg sediment). Laboratory analyses of PCB concentrations in three paint chips samples from the Phase 2 particle size sampling yielded results of 339, 404, and 480 µg/kg for an average of 408 µg/kg. Applying the quantity of paint chips and the average PCB concentration in paint chips yields an estimated post-dredging PCB concentration of 69 µg/kg in stream sediment. Although this residual concentration was developed from suction dredging data, it is reasonable that similar residual concentrations would be observed from mechanical dredging. This condition was modeled by substituting PCB concentrations of 69 µg/kg for each sample in depth intervals H1 and H2 of the Herrera stream sediment data and recalculating the 95% UCL by subreach. For conservatism, this calculation combined all four depth intervals in a given subreach to simulate the condition that PCBs from depth intervals H3 and H4 are mixed with the remediated sediments in H1 and H2 at some point in the future. This condition could occur through mixing of sediment via scour and deposition or from migration of fines toward the surface via piping (i.e., the migration of fine-grained sediment into the voids created by removal of the fine sediment in the upper 6-inch of sediment). The results of the 95% UCL calculations are presented in Table 16, and the results are compared to the pre-dredging 95% UCL. The 95% UCLs of mean PCB concentrations by subreach and the percent the UCL would be reduced by mechanical dredging are as follows:

- Subreach 2A - 218.8 µg/kg (96.8% reduction)
- Subreach 2B - 615.1 µg/kg (6.4% reduction)
- Subreach 3A - 703.3 µg/kg (69.6% reduction)
- Subreach 3B - 151.2 µg/kg (29.5% reduction)

DRAFT

- Subreach 4A - 96.28 µg/kg (9.9% reduction)
- Subreach 4B - 73.98 µg/kg (57.5% reduction)

Mean PCB concentrations in each subreach were also calculated and are presented in Table 16. The mean PCB concentrations by subreach and the percent the mean would be reduced by mechanical dredging are as follows:

- Subreach 2A - 117.5 µg/kg (97.5% reduction)
- Subreach 2B - 174.3 µg/kg (17.3% reduction)
- Subreach 3A - 219.5 µg/kg (76.0% reduction)
- Subreach 3B - 76.01 µg/kg (26.5% reduction)
- Subreach 4A - 58.12 µg/kg (approximately zero)
- Subreach 4B - 62.72 µg/kg (20.2% reduction)

As described in the RI (Olympus, 2009), UCL calculations can be influenced by potential outliers. The post-dredging UCLs in Subreaches 2B and 3A appear to be skewed by a small number of high PCB concentrations. Out of 79 samples in Subreach 2B, only two samples (8,000 and 930 µg/kg) have concentrations greater than the 95% UCL of 615.1 µg/kg. Similarly, of 104 samples in Subreach 3A, only three samples (9,400, 6,900, and 720 µg/kg) have concentrations greater than the 95% UCL of 703.3 µg/kg. Compared to the pre-dredging 95% UCLs of mean PCB concentrations, the post-dredging UCLs are significantly reduced. With the exception of Subreaches 2B and 3A, which are skewed by a small number of high PCB concentration samples, the 95% UCL of mean PCB concentrations in the remaining subreaches are near or below the TMDL provisional target concentration of 189 µg/kg. PCB concentrations in the upper six inches, where aquatic organisms would have a greater likelihood of exposure, would have much lower PCB concentrations. Based on mean PCB concentrations, the only subreach that would not meet the TMDL target concentration of 189 µg/kg is Subreach 3A, which would have a residual mean PCB concentration of 219.5 based on the conservative assumption of complete mixing of the surface and subsurface sediment. Additionally, the estimated residual PCB concentration of 69 µg/kg is likely high because the short duration of the pilot test and the limited number of samples.

The use of the 95% UCL of mean PCB concentrations by subreach to estimate residual PCB concentrations as outlined above is probably conservatively high. Flow events large enough to cause scour and deposition of the deeper sediment would likely move sediment downstream, where it would be dispersed and diluted by mixing with "cleaner" downstream sediment. However, the contaminant fate and transport evaluation (Section 1.2.4) indicates that sediment transport is limited by the flow regime and sediment supply in upper Big Spring Creek.

The second (estimated low residual PCB concentrations) and third (estimated high residual PCB concentrations) conditions evaluated for post-dredging PCB concentrations are variations of the first condition with different residual PCB concentrations in the dredged areas. The results of these evaluations were used to complete a sensitivity analysis of post-remediation 95% UCL calculations. The fish/sediment relationship developed by FWP (Section 1.2.4) indicated that PCB concentrations in stream sediment would likely need to be less than typical analytical detection limits in order to allow for unlimited consumption of fish. Therefore, residual PCB concentrations of zero µg/kg were used for the second condition to estimate a lower bound on the post-remediation 95% UCL of mean PCB concentrations if sediment from deeper layers is mixed with surface sediment. It should be noted that PCB concentrations of zero µg/kg are not measurable because laboratory analytical methods are limited to the lower detection limit, which is always greater than zero. The third condition considered a post-remediation residual

DRAFT

concentration of 100 µg/kg in dredged areas, which represents an estimated high-end for post-remediation conditions in the dredged areas. The sensitivity analysis for post-remediation 95% UCL calculations is presented in Table 17. The 95% UCLs calculated with zero µg/kg residual PCBs ranged from 63.4% to 95.4% of the 95% UCLs calculated with 69 µg/kg of residual PCBs. The 95% UCLs calculated with 100 µg/kg of residual PCBs ranged from 102.1% to 150% of the 95% UCLs calculated with 69 µg/kg of residual PCBs. The larger 95% UCLs generally had the smallest percent changes (relative to 69 µg/kg residual PCB concentrations), while the smallest 95% UCLs had the largest percent changes. For example, a 144% increase (69 to 100 µg/kg) residual PCB concentration resulted in a 2 to 3 percent increase in 95% UCL for the larger UCL values. Although the smaller 95% UCL values showed a larger percent increase, these values are generally less than the TMDL target concentration and are of much less concern than the larger UCL values. Similarly, decreasing the residual PCB concentrations to zero µg/kg resulted in less than a 5 percent decreased the 95% UCLs for the larger UCL values. Thus, the sensitivity analyses show that the 95% UCL calculations are not very sensitive to the assumed residual PCB concentration.

<u>Alternative 2B</u>

The reduction in mean and 95% UCL of mean PCB concentrations by subreach for Alternative 2B was evaluated using the same procedure described above for Alternative 2A. Under Alternative 2B, sediment would be removed from Subreaches 2A, 2B, and 3A using mechanical dredging. Based on the results of the sensitivity analyses completed for Alternative 2A, the assumption used for post-dredging residual PCB concentrations (69 µg/kg) appears reasonable and neither increases (100 µg/kg) nor decreases (zero µg/kg) in this assumed value had a large impact on the results of the 95% UCL calculation for the larger UCL values. Therefore, the evaluation for Alternative 2B was completed using a post-dredging residual PCB concentration of 69 µg/kg. As shown in Table 16, the three highest pre-dredging 95% UCLs of mean PCB concentrations (657.2, 2,315, and 6,761 µg/kg) are from Subreaches 2A, 2B, and 3A, which supports the selection of these subreaches for removal under Alternative 2B.

The results of the mean and 95% UCL calculations are presented in Table 16, and the results are compared to the pre-dredging 95% UCL. The 95% UCLs of mean PCB concentrations by subreach and the percent the UCL would be reduced by mechanical dredging are as follows:

- Subreach 2A - 218.8 µg/kg (96.8% reduction)
- Subreach 2B - 615.1 µg/kg (6.4% reduction)
- Subreach 3A - 703.3 µg/kg (69.6% reduction)
- Subreach 3B – 214.5 µg/kg (0% reduction)
- Subreach 4A – 106.9 µg/kg (0% reduction)
- Subreach 4B – 174.2 µg/kg (0% reduction)

The mean PCB concentrations by subreach and the percent the mean would be reduced by mechanical dredging are as follows:

- Subreach 2A - 117.5 µg/kg (97.5% reduction)
- Subreach 2B - 174.3 µg/kg (17.3% reduction)
- Subreach 3A - 219.5 µg/kg (76.0% reduction)
- Subreach 3B - 103.4 µg/kg (0% reduction)
- Subreach 4A - 52.56 µg/kg (0% reduction)
- Subreach 4B - 78.61 µg/kg (0% reduction)

DRAFT

As was previously concluded for Alternative 2A, the post-dredging UCLs in Subreaches 2B and 3A appear to be skewed by a small number of high PCB concentrations. With the exception of Subreaches 2B and 3A, the 95% UCL of mean PCB concentrations in the remaining subreaches are near or below the TMDL provisional target concentration of 189 µg/kg. PCB concentrations in the upper six inches, where aquatic organisms would have a greater likelihood of exposure, would have much lower PCB concentrations. Based on mean PCB concentrations, the only subreach that would not meet the TMDL target concentration of 189 µg/kg is Subreach 3A, which would have a residual mean PCB concentration of 219.5 based on the conservative assumption of complete mixing of the surface and subsurface sediment. Additionally, the estimated residual PCB concentration of 69 µg/kg is likely high because the short duration of the pilot test and the limited number of samples.

The use of the 95% UCL of mean PCB concentrations by subreach to estimate residual PCB concentrations as outlined above is probably conservatively high. Flow events large enough to cause scour and deposition of the deeper sediment would likely also move sediment downstream, where it would be dispersed and diluted by mixing with “cleaner” downstream sediment.

5.3.2 Compliance With ARARs

A comprehensive list of federal and state ARARs is presented in Section 2.0 and Appendix E. ARARs are divided into contaminant-specific, location-specific, and action-specific requirements.

There are no state contaminant-specific ARARs for PCBs in stream sediment. Under the assumptions of the dredging conditions described above for Alternative 2, the 95% UCL of mean PCB concentrations in sediment (Table 16) would meet the federal chemical-specific ARAR-based PRG of 1 mg/kg (1,000 µg/kg) for PCB remediation waste in high occupancy areas (see Section 3.1.2.1) under both Alternatives 2A and 2B; however, it should be noted that the EPA regional administrator may also require cleanup to more stringent levels based on proximity to areas such as residences, wetlands, fisheries, etc. While not an ARAR, the TMDL target concentration for PCBs in Big Spring Creek of 189 µg/kg is “To Be Considered” (Section 2.0). This concentration is based on the probable effects level developed by EPA (1997). DEQ’s TMDL report calls for the average Aroclor 1254 concentration to be less than 189 µg/kg. The TMDL target concentration would likely be met in the surface sediment after dredging in all subreaches under Alternative 2A. Under Alternative 2B, the TMDL target concentration would not be met in surface sediment in Subreaches 3B and 4B; however, it is expected that PCB concentrations would decrease over time since the upstream source would be removed and clean sediment would be transported through these subreaches. As shown in Table 16, conservative estimates of post-dredging 95% UCLs of mean PCB concentrations that consider mixing of deeper (undredged) sediment with surface sediment at some time in the future would slightly exceed the TMDL target concentration in Subreach 2A, and would meet the target in Subreaches 3B, 4A, and 4B. The TMDL target would not be met in Subreaches 2B and 3A; however, the UCLs in these subreaches are skewed by a small number of high PCB concentration samples.

The TMDL target concentration for PCBs in fish tissue (<0.025 mg/kg) would not likely be met in this alternative given the potential residual level of PCBs in sediment (69 µg/kg) based on observations from the pilot test. However, fish tissue PCB concentrations are expected to

DRAFT

decrease, and potentially would fall below 0.12 mg/kg (site-specific risk assessment target), which would allow for some limited consumption of fish.

Six surface water samples were collected from Reaches 2, 3, and 4 of Big Spring Creek during the risk assessment (CDM, 2005), and PCBs were not detected in these samples. The detection limit for PCBs was less than the EPA drinking water maximum contaminant level (MCL) of 0.5 µg/L and the DEQ surface water criterion of 0.014 µg/L for protection of aquatic life. Therefore, contaminant-specific ARARS for PCBs are currently being met in surface water in Big Spring Creek. Contaminant-specific ARARs for surface water would need to be met during mechanical dredging and would require monitoring.

Implementation of this alternative is expected to satisfy air quality regulations because disposal of PCB-impacted sediment in a solid waste landfill would stabilize contaminant sources and inhibit fugitive emissions.

Location-specific ARARs are expected to be met in the implementation of this alternative. Contacts with the appropriate agencies and acquisition of required permits related to streambeds, floodplains, and archaeological/paleontological resources would be completed.

Action-specific ARARs are expected to be met including the disposal requirements of TSCA and the hydrological regulations contained in the Strip and Underground Mine Reclamation Act. Dredging activities would require coordination with the Montana Fish, Wildlife, and Parks Department, The U.S. Army Corps of Engineers, the Montana Department of Natural Resources and Conservation, and possibly the Fergus County Conservation District. Revegetation requirements contained in the Surface Mining and Control Reclamation Act would be met. State of Montana air quality regulations related to dust suppression and control during construction activities would be met using water sprays where applicable, i.e. staging areas and haul roads with heavy vehicular traffic.

Occupational Safety and Health Administration (OSHA) requirements would be met by requiring appropriate safety training for all on-site workers during the construction phase. Site activities would be conducted under the guidance of a Health and Safety Plan for the site as per OSHA 29 CFR 1910.120. Site personnel would have completed 40-hour hazardous waste operations and emergency response training and would be current on the 8-hour annual refresher training as required by OSHA.

DRAFT

5.3.3 Long-Term Effectiveness and Permanence

This alternative would reduce contaminant mobility at the site by removing the most highly contaminated sediment and disposing of the waste in a permitted Class II landfill; however, not all contaminated sediment would be removed under Alternative 2. Remaining PCB-impacted sediment would be left in-place in the stream bed. PCB concentrations in fish tissue and other aquatic and terrestrial organisms are expected to be reduced; however, the degree of reduction would not be known until monitoring is completed after remediation has occurred. Reliable monitoring results to show reductions in PCBs in fish tissue would take several years to obtain. Rainbow and brown trout in the creek are currently impacted with PCBs. Therefore, it would take an estimated 6 to 8 years for new generations of fish that have not previously been impacted by PCBs to grow to the appropriate size for sampling and accurately reflect the post-remediation PCB concentrations in fish tissue. FWP protocols for monitoring fish in Big Spring

Creek include the collection of rainbow trout (13-15 inches total length) and brown trout (14-16 inches total length).

The known sources of PCBs in paint associated with the hatchery raceways and other areas that may discharge to Big Spring Creek have been removed or encapsulated. Thus, reductions in the mass of PCBs in the stream are expected to be permanent. Since PCBs would remain in a portion of the stream sediment under this alternative, PCBs can still be mobilized and transported downstream, which reduces the long-term effectiveness when compared to alternatives with complete removal. Additionally, UCL calculations (Section 5.4.1) based on assumed residual PCB concentrations in dredged areas show that removal of PCBs from the upper six inches of sediment substantially reduces the 95% UCL of mean PCB concentrations even if the sediment in deeper zones mixes with sediment from the shallow layers.

After dewatering, the PCB-impacted stream sediment would be encapsulated in a permitted Class II landfill, which would effectively isolate this waste and reduce contaminant mobility. This alternative achieves long-term risk reduction by transporting the contaminated materials to a facility that specializes in the storage and disposal of non-hazardous wastes, thus ensuring the long-term permanence of the remedy. The portion of the impacted sediment that remains in the stream reduces the long-term effectiveness of this alternative compared to complete removal alternatives. Although the degree of habitat destruction from Alternative 2 would be less than the complete removal alternatives, sediment of all sizes would still be removed from the upper 6 inches of the stream bed. The sediment would be screened, sorted, and the oversize material replaced into the stream. This would require extensive stream reconstruction to restore the geomorphic and habitat features of the stream.

DRAFT

5.3.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

Reduction of contaminant mobility is the primary objective of this alternative. The volume and toxicity of the contaminants in the waste materials would not be physically or chemically reduced. The partial removal of the impacted sediment from Big Spring Creek would reduce the contaminant mobility by moving a portion of the waste to a secure location. The waste materials would be encapsulated in an engineered landfill cell, which is protected from erosion and water infiltration. It is possible that PCBs could be remobilized from deeper in the streambed over time since a portion of the PCB-impacted sediment would be left in place. High flow conditions could cause scour and redeposition of PCB-impacted sediment that remains after mechanical dredging is completed. However, the limited nature of the flow regime in Big Spring Creek (Section 1.2.4) is favorable for limiting scour and redeposition of sediment. The consistent flow from the Big Spring and flow attenuation from Hansen Creek dam tend to limit the amount of sediment transport and upstream sediment supply from tributaries to Big Spring Creek. The limited flow regime is supported by the PCB concentration data. Although stream sediment and fish tissue sampling have documented PCB impacts several miles downstream from the hatchery sources, the highest PCB concentrations are still observed in the area directly below each hatchery. This shows that contaminant mobility is naturally limited by the system. Removal of PCBs from the upper layers of sediment would further limit the mobility of PCBs and supports the long-term effectiveness of this alternative with a lesser amount of habitat disturbance compared to the complete removal alternatives.

5.3.5 Short-Term Effectiveness

5.3.5.1 General

It is anticipated that construction activities related to the implementation of this alternative would be completed in one construction season. Impacts associated with construction activities should not significantly impact human health or the environment. On-site workers would be protected by following a site-specific Health and Safety Plan, employing appropriate personal protective equipment and by following proper operating and safety procedures. Short term water quality impacts, including resuspension and redeposition of PCB-laden sediment, would occur while mechanically dredging. Mechanical dredging would likely have greater impacts on water quality compared to both hydraulic dredging and dry excavation. Best management practices to control erosion and sedimentation during mechanical dredging are essential to the success of this alternative.

Short term air quality impacts to the immediate environment may occur due to the relatively large volume of dredging and hauling of sediment. The wet nature of the sediment should control fugitive dust; however, dry sediment being stored prior to hauling to the landfill may require the use of water spray to control fugitive dust. The use of heavy equipment and haul trucks, and the need for haul roads, staging areas, and sediment processing areas would impact local residents in the project area during construction activities. Other short-term impacts to local residents would include potential noise and dust from construction activities. Noise can be controlled through the use of set working hours. Control of fugitive dust may require the use of water sprays.

On-site workers would be protected by following a site specific Health and Safety Plan, employing appropriate personal protective equipment, and by following proper operating and safety procedures. However, short term air quality impacts to the immediate environment may occur due to the relatively large volume of dredging and hauling of PCB-impacted sediment. Control of fugitive dust may require the use of water sprays.

Impacts to the surrounding community are expected to be minimal due to the location of the project site. The most significant short-term impact to the surrounding community would involve increased vehicle traffic, particularly haul truck traffic, with associated safety hazards and potential dust generation. A traffic control plan, including warning signs and possibly flaggers, would be required while transporting these wastes.

DRAFT

5.3.5.2 Alternative 2A

Direct Effects on Biota. Under Alternative 2A, partial removal (upper 6-inches) via mechanical dredging would be conducted in all subreaches of the upper creek. Mechanical dredging is considered to be the most invasive and destructive alternative affecting aquatic life in the stream. Removing the upper 6-inches via mechanical dredging from all subreaches would remove all periphyton, rooted aquatic plants, and invertebrates from the creek. As remediation moves downstream, most fish would eventually be driven out of the entire upper section of the creek to areas below the confluence with the East Fork, leaving the upper section largely fishless until the channel is re-graded with fresh material and invertebrates recolonize the area. Fish driven downstream would compete for habitat and food with fish inhabiting the lower sections and could result in reduced growth and even mortality depending on the resource availability and partitioning.

Direct adult and juvenile trout mortality should be low for these mobile organisms. Fish eggs and sac fry found in the gravels during dredging would likely have 100% mortality. Dredging time restrictions could minimize this loss. It would probably take an estimated 4 months to dredge the entire 2.77 miles, so there is potential that only a portion of the project area would be dredged during the critical spawning and rearing period. Surveys conducted on Big Spring Creek indicate brown trout spawn between mid-October and late November. Brown trout eggs hatch during the winter and the sac fry probably stay in the gravels until March. Spawning for rainbow trout likely runs from March through May, with swim-up (emergence from the gravels) occurring somewhere between early June and late July. If dredging is postponed until after trout swim-up in June or July, mortality of young-of-the-year (YOY) rainbow trout should be reduced. Length of dredging time and seasonality of dredging may make such time restrictions impractical or require dredging over two seasons. Survival of eggs and fry would not likely occur in the streambed cobbles of riffle crests that are not dredged to preserve stream stability. It is unlikely that reproduction from brown trout in the upper 2.77 miles of Big Spring Creek provides much recruitment to Big Spring Creek; dredging impacts to brown trout reproduction in this reach would likely have little impact on brown trout numbers in Big Spring Creek. However, rainbow trout spawning in the 2.77 miles below the upper hatchery may contribute substantially to the rainbow trout population in Big Spring Creek.

Recolonization. The length of time anticipated for recolonization of fish, invertebrates, rooted aquatic plants, and periphyton to the upper creek under Alternative 2A would likely be long compared with all other alternatives. Unfortunately, the most impacted areas of the creek are near the source of the creek, leaving only two small tributaries (Hansen Creek and Castle Creek) that would serve as an upstream source of plants and animals to assist in the recolonization of the dredged portion of the creek.

Fish. Under this alternative, fish would be driven out of the upper section of the creek due to dredging activities. The length of time required to mechanically dredge under this alternative would likely overlap the spawning and/or incubation period of both spring spawning rainbow trout and fall spawning brown trout. Impacts to spawning fish likely extend beyond actual physical removal and destruction during dredging by reducing sediment stability until after a high flow period (Harvey and Lisle 1998). Even when the creek is rebuilt, it may take several years for the periphyton, aquatic vegetation, and invertebrates to return to the remediated sections of the creek that would allow fish to recolonize the area in any significant numbers.

Invertebrates. Under this alternative, invertebrates would be completely removed from the upper creek. This impact would be similar to what is seen following rotenone treatments used to kill fish from streams. In these studies, invertebrate communities, in terms of taxa richness and abundances, essentially returned to pre-treatment conditions within 2 years (Whelan 2002), although some recolonization was evident as soon as several months after the treatments. This same length of time for invertebrate recolonization would be anticipated under this alternative.

Aquatic Plants. Under this alternative, all aquatic plants and seed banks stored in the sediment would be completely removed from the upper creek. Upstream seed sources, albeit limited, would likely begin to re-establish aquatic plants within 2 years following completion of the project. Waterfowl activity and movement, prominent in the creek, may assist in spreading new seeds to the remediated areas. Even so, it may take several years for aquatic vegetation to return to conditions seen prior to dredging actions.

DRAFT

Terrestrial Vegetation. Under this alternative, much of the woody plants on both streambanks along the entire length of the upper creek would be damaged or removed due to the need for excavator operators to have adequate range of motion for activities and unimpeded view of the stream. Depending on the extent of damage, vegetation would regain original size and vigor in 2-5 years.

5.3.5.3 Alternative 2B

Direct Effects on Biota. Under Alternative 2B, partial removal (upper 6-inches) via mechanical dredging would be conducted in the upper 3 subreaches of the upper creek. Mechanical dredging is considered to be the most invasive and destructive alternative affecting aquatic life in the stream. Removing the upper 6-inches via mechanical dredging from the upper 3 subreaches would remove all periphyton, rooted aquatic plants, and invertebrates from those sections of the creek. As remediation moves downstream, most fish would eventually be driven out of the upper 3 subreaches to downstream sections, leaving the upper creek largely fishless until the channel is re-graded with fresh material and invertebrates recolonize the area. Fish driven downstream would compete for habitat and food with fish inhabiting the lower sections and could result in reduced growth and even mortality depending on the resource availability and partitioning. The impact to the biota from this alternative would be similar to alternative 2A within the remediated sections.

Direct adult and juvenile trout mortality should be low for these mobile organisms. Fish eggs and sac fry found in the gravel during dredging would likely have 100% mortality. Dredging time restrictions could minimize this loss. It would take an estimated 2 months to dredge the entire 1.25 miles, so there is potential that only a portion of the project area would be dredged during the critical spawning and rearing period. Surveys conducted on Big Spring Creek indicate brown trout spawn between mid-October and late November. Brown trout eggs hatch during the winter and the sac fry probably stay in the gravels until March. Spawning for rainbow trout likely runs from March through May, with swim-up (emergence from the gravels) occurring somewhere between early June and late July. If dredging is postponed until after trout swim-up in June or July, mortality of YOY rainbow trout should be reduced. Survival of eggs and fry would not likely occur in the streambed cobbles of riffle crests that are not dredged to preserve stream stability. It is unlikely that reproduction from brown trout in the upper 1.25 miles of Big Spring Creek provides much recruitment to Big Spring Creek; dredging impacts to brown trout reproduction in this reach would likely have little impact on brown trout numbers in Big Spring Creek. However, rainbow trout spawning in the 1.25 miles below the upper hatchery may contribute substantially to the rainbow trout population in Big Spring Creek.

Recolonization. The length of time anticipated for recolonization of fish, invertebrates, rooted aquatic plants, and periphyton to the upper creek under Alternative 2B would likely be longer than the dry excavation or hydraulic dredging alternatives, but less than alternative 2A because the area being remediated in 2B is less, and would likely allow for faster recolonization. Unfortunately, the most impacted areas of the creek are near the source of the creek, leaving only two small tributaries (Hansen and Castle Creek) that would serve as an upstream source of plants and animals to assist in the recolonization of the dredged portion of the creek.

Fish. Under this alternative, fish would be driven out of the upper 3 subreaches of the creek due to dredging activities. The length of time required to mechanically dredge under this alternative may overlap the spawning period of both spring spawning rainbow trout and fall spawning brown trout, but because less area would be dredged compared to 2A, it is possible

DRAFT

spawning periods could be avoided. Impacts to spawning fish likely extend beyond actual physical removal and destruction during dredging by reducing sediment stability until after a high flow period (Harvey and Lisle 1998). Even when the creek is rebuilt, it may take several years for the periphyton, aquatic vegetation, and invertebrates to return to the remediated sections of the creek that would allow fish to recolonize the area in any significant numbers.

Invertebrates. Under this alternative, invertebrates would be completely removed from the upper 3 subreaches of the creek. This impact would be similar to what is seen following rotenone treatments used to kill fish from streams. In these studies, invertebrate communities, both taxa richness and abundances, essentially returned to pre-treatment conditions within 2 years (Whelan 2002) although some recolonization was evident as soon as several months after the treatments. This same length of time for invertebrate recolonization would be anticipated under this alternative, although recolonization may occur faster than alternative 2A because less area of the creek would be impacted.

Aquatic Plants. Under this alternative, all aquatic plants and seed banks stored in the sediment would be completely removed from the upper 3 subreaches of the creek. Upstream seed sources, albeit limited, would likely begin to re-establish aquatic plants within 2 years following completion of the project. Waterfowl activity and movement, prominent in the creek, may assist in spreading new seeds to the remediated areas. Even so, it may take several years for aquatic vegetation to return to conditions seen prior to dredging actions, although recolonization may occur faster than alternative 2A because less area of the creek would be impacted.

Terrestrial Vegetation. Under this alternative, much of the woody plants on both streambanks along the uppermost 1.25 miles of the upper creek would be damaged or removed due to the need for excavator operators to have adequate range of motion for activities and unimpeded view of the stream. This impact would be less than alternative 2A due to the shorter stream length impacted. Depending on the extent of damage, vegetation would regain original size and vigor in 2-5 years.

5.3.6 Implementability

This alternative is technically implementable. Sediment removal, transportation and disposal, and stream restoration are readily implementable using commercially available equipment and materials. Stream restoration has been successfully completed on numerous streams and is a proven technology, if implemented correctly. Key project components, such as the availability of equipment, construction expertise, and sufficient landfill space, are present and would aid in the timely implementation and successful execution of the proposed project.

The administrative feasibility of this alternative is questionable. The degree of habitat destruction, the high potential for resuspension and mobilization of PCBs, and the degree of streambank vegetation that would need to be removed make this alternative unattractive for FWP to be able to issue a Stream Protection Act 124 permit.

5.3.7 Cost

The total present-worth cost for this alternative has been estimated at $2,803194 for Alternative 2A and $1,487,862 for Alternative 2B. The assumptions for used in estimating these costs are

DRAFT

presented in Table 18. Table 19 and Table 20 present the cost details associated with implementing Alternative 2A and 2B, respectively. The total cost includes the present-worth value of 30 years of annual maintenance and monitoring costs in addition to capital costs. The total cost includes the present-worth value of 30 years of annual maintenance and monitoring costs in addition to capital costs.

Conceptual Design and Assumptions

Mechanical dredging would be completed using conventional excavation equipment such as hydraulic excavators and off-road haul trucks to remove streambed sediment to an approximate depth of 6 inches. The 6-inch depth would be variable because of the presence of cobbles that are larger than 6 inches in thickness. The sediment would be saturated and additional water would be entrained in the bucket as the sediment is excavated. Therefore, lined storage ponds would be required to temporarily store and dewater the sediment. The water would require settlement in ponds or treatment/filtration to remove suspended sediment which could contain PCBs. After treatment, the water would be discharged to Big Spring Creek or land applied.

Additional processing of sediment would include screening/sorting of the sediment to recover oversize material (>1/4 inch), segregating and collecting the fine sediment fraction, and dewatering of the sediment prior to transportation and disposal. The oversize material would be sorted and blended into gradations based on the geomorphic type (i.e., riffle, run, pool, etc.). Supplemental fines (i.e., 1/4-inch minus) would be blended in as necessary to achieve gradations similar to the pre-excavation condition. The blended oversize material would then be returned to the streambed based on geomorphic type and the streambed reconstructed to near the original condition. Placing the blended sediment in presence of flowing water may be conducive to erosion and sedimentation of the fine fraction, which is potentially problematic. Streambanks would be left undisturbed to the extent practical; however, equipment access, haul roads, and haul truck traffic would likely necessitate some streambank reconstruction.

To implement this alternative, vegetation would need to be removed from the majority of the streambank, at least on one side of the stream, to allow access and effective loading of haul trucks. Vegetation removal could potentially be lessened through the use of conveyor systems that could span over the vegetation. Damaged vegetation would be replaced with like materials, but not necessarily the same size.

DRAFT

The water and suspended sediment collected from the sediment dewatering could be pumped to a settling tank for the first stage of water treatment. A flocculant, such as Chitosan, can be added to increase the settling velocity of fine particles and reduce the required holding time in the settling tank. A preliminary bench-scale test of Chitosan on fine sediment collected from Big Spring Creek indicated that suspended sediment rapidly settled with the addition of a Chitosan solution, while suspended sediment in a control sample without Chitosan did not rapidly settle.

After the initial treatment in a settling tank, the water can be treated through sand filters and, if necessary, a series of bag filters (i.e., 25, 5, and 1 micron filters) to “polish” the water prior to discharge into Big Spring creek. Both turbidity and PCBs would be monitored to verify compliance with the terms of the 318 permit issued by DEQ.

After dewatering is completed, the sediment would be loaded into a haul truck for transportation to the landfill. The sediment would likely be disposed of at the Montana Waste Systems High Plains Landfill located in Great Falls, Montana.

Temporary sediment storage and processing areas would be selected to minimize disturbance to vegetation and developed areas. Relatively flat open areas, such as meadows or pasture areas, would be suitable for sediment storage and processing areas. At the completion of the project, these areas would be graded to the approximate original contour, and seeded with a mixture of native grasses.

The general construction steps for implementing Alternative 2 are as follows:

- site preparation including road improvements and clearing and grubbing;
- preparation of temporary sediment storage and processing (dewatering, screening/sorting, water collection and treatment) areas;
- mechanical dredging of streambed sediment;
- hauling sediment to temporary staging and processing areas;
- screening of sediment to remove oversize material (material larger than approximately 1/4-inch;
- dewatering of sediment so that free-draining liquids are removed;
- collection and treatment of water and suspended sediment from the dewatering operation;
- monitoring of PCB concentrations and turbidity levels in the treated water;
- discharge of treated water to Big Spring Creek;
- collection and loading of dewatered sediment into trucks and hauling to the landfill;
- sorting the oversize material into gradations based on geomorphic type that approximate the pre-construction condition, including the addition of 1/4-inch minus material;
- hauling the oversize material and placing it back in the streambed;
- restoring the streambed to near the pre-excavation condition;
- removal and reclamation of stream diversions, haul roads, and temporary sediment staging and storage areas; and
- re-establishing vegetation in disturbed areas.

Mechanical dredging offers the following advantages over other technologies:

- removes sediment at nearly the in-situ water content (lower than hydraulic dredging); and
- requires less sediment dewatering than hydraulic dredging

Disadvantages of mechanical dredging include:

DRAFT

- requires extensive haul roads along creek;
- destructive to stream bank and vegetation from equipment and haul trucks;
- removes all sediment regardless of size;
- requires large staging area(s) for screening/sorting and dewatering;
- requires screening/sorting of the sediment to capture and reuse oversize material;
- high probability for resuspension and redeposition of PCB-laden sediment on the streambed;
- removal and replacement of material in the upper 6 inches would likely cause more habitat disturbance and potential streambed and/or streambank instability than hydraulic dredging; and
- requires extensive stream reconstruction/restoration

5.4 Alternative 3: Partial Removal of PCB-Impacted Stream Sediment Via Hydraulic Dredge with Disposal at a Solid Waste Landfill

The remediation strategy for Alternative 3 involves partial removal of PCB-impacted stream sediment via hydraulic dredging. Given the small size and limited depth of Big Spring Creek, sediment would likely be dredged from the streambed using a 4- or 6-inch portable suction dredge. Suction dredging involves the use of a pump to create suction and remove sediment in a slurry form. The sediment slurry would be dewatered and the water would be treated and either discharged back into the creek or land applied. The dewatered sediment would be transported via truck to a permitted Class II municipal solid waste landfill for disposal.

Two partial removal scenarios are considered under Alternative 3. Alternative 3A considers the removal of sediment from the upper 6 inches from Subreaches 2A through 4B. Alternative 3B considers the removal of the upper 6 inches of sediment from Subreaches 2A, 2B, and 3A. The rationale for these removal scenarios is presented in Section 5.1. Under Alternative 3B, Subreaches 3B, 4A, and 4B would be monitored according to MNR procedures since remediation would not occur in these areas.

The suction dredge pilot test that was completed in the fall of 2006 (Section 1.2.7) showed that a small suction dredge could be used to remove fine sediment to a depth of about 5 to 7 inches. Therefore, a 6-inch removal is a reasonable performance objective for suction dredging. The 6-inch removal depth also approximately corresponds to the sediment layers with the highest PCB concentrations (Table 2 through Table 5).

Dewatering of sediment and treatment of the slurry water could be accomplished by a variety of methods including settling ponds, geotextile tubes, or commercially available treatment systems. The following describes a commercially available system that has been used to treat dredge slurry from other PCB cleanup projects. Dredge slurry could be pumped into a series of filter boxes to dewater the sediment. A filter box is a 25 cubic yard metal box that is lined with a geotextile filter fabric. The geotextile filter fabric retains the sediment, while allowing the water to drain. The sediment retained on the filter fabric is then recovered from the filter box and

DRAFT

segregated for disposal. Sediment that is allowed to drain in a filter box should pass the “paint filter test”, which is the standard used to determine if free-draining liquids are present. Solid waste landfills cannot accept wastes with free-draining liquids.

Water and suspended sediment that pass through the filter fabric would be collected in the base of the filter box and treated prior to being discharged back into Big Spring Creek. The water could be treated in a number of ways. A common method is a multi-stage process of settling and filtration. Chitosan, a flocculant derived from crustacean shells (crab, shrimp, and lobster), can be added to the water and suspended sediment mixture to decrease the settling time for colloidal particles if necessary. After passing through a settling tank, the water could then pass through sand filters and be “polished” through a series of bag filters (i.e., 25 micron, 5 micron, and 1 micron) as necessary to achieve water quality standards for PCBs and turbidity prior to discharging the water back into Big Spring Creek.

5.4.1 Overall Protection of Human Health and the Environment

As shown in the human health risk assessments (CDM, 2005, 2008, and 2009), the only significant risk to human health is the consumption of PCB-impacted fish. Risks to human health from exposure via direct contact or ingestion of stream sediment and direct contact or ingestion of stream water were not significant.

The implementation of this alternative would provide a means of reducing the risk to both human health and the environment. Partial removal of PCB-impacted sediment, particularly removal of sediment from areas with the highest concentration of PCBs, would reduce the degree of exposure to both aquatic organisms and terrestrial organisms that feed on aquatic organisms. The risk to human health from consumption of PCB-impacted fish would also be reduced accordingly. However, partial removal would leave some PCB-impacted sediment in place so the exposure pathway would be reduced, but not eliminated. Therefore, exposure of aquatic organisms to PCBs, while reduced, would still exist. Similarly, the exposure of terrestrial organisms that feed on aquatic organisms would be reduced compared to the no action alternative, but would still exist. Human exposure to PCBs from consumption of fish would be reduced under this alternative, but would still exist. Institutional controls, such as fish consumption advisories and catch and release only fishing regulations, will remain in effect at the Site until it is demonstrated that PCBs in fish tissue are at concentrations that are safe for human consumption.

DRAFT

<u>Alternative 3A</u>

The degree of risk reduction is difficult to quantify because of the high variability of the PCBs in stream sediment data, the variability in the fish tissue/stream sediment relationship, and in estimating the post-dredging residual PCB in sediment concentrations. To estimate the degree of risk reduction under Alternative 3A, assumptions have been made about post-remediation residual PCB concentrations, and mean PCB concentrations and 95% UCLs of mean PCB concentrations have been calculated for these conditions and compared to the existing (pre-dredging) mean and 95% UCL to evaluate risk reduction. The 95% UCLs were calculated using EPA’s ProUCL statistical software package (EPA, 2007a and 2007b). The pre-dredging mean PCB concentrations are shown in Table 16, and range from 4,785 µg/kg in Subreach 2A to 52.56 in Subreach 4A. The pre-dredging 95% UCLs of mean PCB concentrations are shown in Table 16, and range from 6,761 µg/kg in Subreach 2A to 106.9 µg/kg in Subreach 4A. ProUCL calculations are presented in Appendix G.

Three conditions have been evaluated for post-dredging PCB concentrations in stream sediment (0, 69, and 100 µg/kg in order to test the sensitivity of the model to effectiveness of PCB removal). The estimated residual PCB concentrations for the first condition were based on an data from the suction dredge pilot test (Section 1.2.7). The quantity of paint chips found in five post-dredging core samples was an average 0.017% (i.e., 0.00017 mg paint per mg sediment). Laboratory analyses of PCB concentrations in three paint chips samples from the Phase 2 particle size sampling yielded results of 339, 404, and 480 µg/kg for an average of 408 µg/kg. Applying the quantity of paint chips and the average PCB concentration in paint chips yields an estimated post-dredging PCB concentration of 69 µg/kg in stream sediment. This condition was modeled by substituting PCB concentrations of 69 µg/kg (the typical lower detection limit achieved during the Phase 1 RI sampling) for each sample in depth intervals H1 and H2 of the Herrera stream sediment data and recalculating the 95% UCL by subreach. For conservatism, this calculation combined all four depth intervals in a given subreach to simulate the condition that PCBs from depth intervals H3 and H4 are mixed with the remediated sediments in H1 and H2 at some point in the future. This condition could occur through mixing of sediment via scour and deposition or from migration of fines toward the surface via piping (i.e., the migration of fine-grained sediment into the voids created by removal of the fine sediment in the upper 6-inch of sediment). The results of the 95% UCL calculations are presented in Table 16, and the results are compared to the pre-dredging 95% UCL. The 95% UCLs of mean PCB concentrations by subreach and the percent the UCL would be reduced by suction dredging are as follows:

- Subreach 2A - 218.8 µg/kg (96.8% reduction)
- Subreach 2B - 615.1 µg/kg (6.4% reduction)
- Subreach 3A - 703.3 µg/kg (69.6% reduction)
- Subreach 3B - 151.2 µg/kg (29.5% reduction)
- Subreach 4A - 96.28 µg/kg (9.9% reduction)
- Subreach 4B - 73.98 µg/kg (57.5% reduction)

Mean PCB concentrations in each subreach were also calculated and are presented in Table 16. The mean PCB concentrations by subreach and the percent the mean would be reduced by mechanical dredging are as follows:

- Subreach 2A - 117.5 µg/kg (97.5% reduction)
- Subreach 2B - 174.3 µg/kg (17.3% reduction)
- Subreach 3A - 219.5 µg/kg (76.0% reduction)
- Subreach 3B - 76.01 µg/kg (26.5% reduction)
- Subreach 4A - 58.12 µg/kg (approximately zero)
- Subreach 4B - 62.72 µg/kg (20.2% reduction)

As described in the RI (Olympus, 2009), UCL calculations can be influenced by potential outliers. The post-dredging UCLs in Subreaches 2B and 3A appear to be skewed by a small number of high PCB concentrations. Out of 79 samples in Subreach 2B, only two samples (8,000 and 930 µg/kg) have concentrations greater than the 95% UCL of 615.1 µg/kg. Similarly, of 104 samples in Subreach 3A, only three samples (9,400, 6,900, and 720 µg/kg) have concentrations greater than the 95% UCL of 703.3 µg/kg. Compared to the pre-dredging 95% UCLs of mean PCB concentrations, the post-dredging UCLs are significantly reduced. With the exception of Subreaches 2B and 3A, which are skewed by a small number of high PCB concentration samples, the 95% UCL of mean PCB concentrations in the remaining subreaches are near or below the TMDL provisional target concentration of 189 µg/kg. PCB concentrations

DRAFT

in the upper six inches, where aquatic organisms would have a greater likelihood of exposure, would have much lower PCB concentrations. Based on mean PCB concentrations, the only subreach that would not meet the TMDL target concentration of 189 µg/kg is Subreach 3A, which would have a residual mean PCB concentration of 219.5 based on the conservative assumption of complete mixing of the surface and subsurface sediment. Additionally, the estimated residual PCB concentration of 69 µg/kg is likely high because the short duration of the pilot test and the limited number of samples.

The use of the 95% UCL of mean PCB concentrations by subreach to estimate residual PCB concentrations as outlined above is probably conservatively high. Flow events large enough to cause scour and deposition of the deeper sediment would likely move sediment downstream, where it would be dispersed and diluted by mixing with “cleaner” downstream sediment. However, the contaminant fate and transport evaluation (Section 1.2.4) indicates that sediment transport is limited by the flow regime and sediment supply in upper Big Spring Creek.

The second (estimated low residual PCB concentrations) and third (estimated high residual PCB concentrations) conditions evaluated for post-dredging PCB concentrations are variations of the first condition with different assumed residual PCB concentrations in the dredged areas. The results of these evaluations were used to complete a sensitivity analysis of post-remediation 95% UCL calculations. The fish/sediment relationship developed by FWP (Section 3.1.2.3) indicated that PCB concentrations in stream sediment would likely need to be less than typical analytical detection limits in order to allow for unlimited consumption of fish. Therefore, residual PCB concentrations of zero µg/kg were used for the second condition to estimate a lower bound on the post-remediation 95% UCL of mean PCB concentrations if sediment from deeper layers is mixed with surface sediment. It should be noted that PCB concentrations of zero µg/kg are not measurable because laboratory analytical methods are limited to the lower detection limit, which is always greater than zero. The third condition considered a post-remediation residual concentration of 100 µg/kg in dredged areas, which represents an estimated high-end for post-remediation conditions in the dredged areas. The sensitivity analysis for post-remediation 95% UCL calculations is presented in Table 17.

The 95% UCLs calculated with zero µg/kg residual PCBs ranged from 63.4% to 95.4% of the 95% UCLs calculated with 69 µg/kg of residual PCBs. The 95% UCLs calculated with 100 µg/kg of residual PCBs ranged from 102.1% to 150% of the 95% UCLs calculated with 69 µg/kg of residual PCBs. The larger 95% UCLs generally had the smallest percent changes (relative to 69 µg/kg residual PCB concentrations), while the smallest 95% UCLs had the largest percent changes. For example, a 144% increase (69 to 100 µg/kg) residual PCB concentration resulted in a 2 to 3 percent increase in 95% UCL for the larger UCL values. Although the smaller 95% UCL values showed a larger percent increase, these values are generally less than the TMDL target concentration and are of much less concern than the larger UCL values. Similarly, decreasing the residual PCB concentrations to zero µg/kg resulted in less than a 5 percent decreased the 95% UCLs for the larger UCL values. Thus, the sensitivity analyses show that the 95% UCL calculations are not very sensitive to the assumed residual PCB concentration.

<u>Alternative 3B</u>

The reduction in mean and 95% UCL of mean PCB concentrations by subreach for Alternative 3B was evaluated using the same procedure described above for Alternative 3A. Under Alternative 3B, sediment would be removed from Subreaches 2A, 2B, and 3A using a portable suction dredge. Based on the results of the sensitivity analyses completed for Alternative 3A, the assumption used for post-dredging residual PCB concentrations (69 µg/kg) appears

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reasonable and neither increases (100 µg/kg) nor decreases (zero µg/kg) in this assumed value had a large impact on the results of the 95% UCL calculation for the larger UCL values. Therefore, the evaluation for Alternative 3B was completed using a post-dredging residual PCB concentration of 69 µg/kg. As shown in Table 16, the three highest pre-dredging 95% UCLs of mean PCB concentrations (657.2, 2,315, and 6,761 µg/kg) are from Subreaches 2A, 2B, and 3A, which supports the selection of these subreaches for removal under Alternative 3B.

The results of the mean and 95% UCL calculations are presented in Table 16, and the results are compared to the pre-dredging 95% UCL. The 95% UCLs of mean PCB concentrations by subreach and the percent the UCL would be reduced by suction dredging are as follows:

- Subreach 2A - 218.8 µg/kg (96.8% reduction)
- Subreach 2B - 615.1 µg/kg (6.4% reduction)
- Subreach 3A - 703.3 µg/kg (69.6% reduction)
- Subreach 3B – 214.5 µg/kg (0% reduction)
- Subreach 4A – 106.9 µg/kg (0% reduction)
- Subreach 4B – 174.2 µg/kg (0% reduction)

The mean PCB concentrations by subreach and the percent the mean would be reduced by mechanical dredging are as follows:

- Subreach 2A - 117.5 µg/kg (97.5% reduction)
- Subreach 2B - 174.3 µg/kg (17.3% reduction)
- Subreach 3A - 219.5 µg/kg (76.0% reduction)
- Subreach 3B - 103.4 µg/kg (0% reduction)
- Subreach 4A - 52.56 µg/kg (0% reduction)
- Subreach 4B - 78.61 µg/kg (0% reduction)

As was previously concluded for Alternative 3A, the post-dredging UCLs in Subreaches 2B and 3A appear to be skewed by a small number of high PCB concentrations. With the exception of Subreaches 2B and 3A, the 95% UCL of mean PCB concentrations in the remaining subreaches are near or below the TMDL provisional target concentration of 189 µg/kg. PCB concentrations in the upper six inches, where aquatic organisms would have a greater likelihood of exposure, would have much lower PCB concentrations. Based on mean PCB concentrations, the only subreach that would not meet the TMDL target concentration of 189 µg/kg is Subreach 3A, which would have a residual mean PCB concentration of 219.5 based on the conservative assumption of complete mixing of the surface and subsurface sediment. Additionally, the estimated residual PCB concentration of 69 µg/kg is likely high because the short duration of the pilot test and the limited number of samples.

The use of the 95% UCL of mean PCB concentrations by subreach to estimate residual PCB concentrations as outlined above is probably conservatively high. Flow events large enough to cause scour and deposition of the deeper sediment would likely also move sediment downstream, where it would be dispersed and diluted by mixing with "cleaner" downstream sediment.

DRAFT

5.4.2 Compliance With ARARs

A comprehensive list of federal and state ARARs is presented in Section 2.0 and Appendix E. ARARs are divided into contaminant-specific, location-specific, and action-specific requirements.

There are no state contaminant-specific ARARs for PCBs in stream sediment. Under the assumptions of the dredging conditions described above for Alternative 3, the 95% UCL of mean PCB concentrations in sediment (Table 16) would meet the federal chemical-specific ARAR-based PRG of 1 mg/kg (1,000 µg/kg) for PCB remediation waste in high occupancy areas (see Section 3.1.2.1) under both Alternatives 3A and 3B; however, it should be noted that the EPA regional administrator may also require cleanup to more stringent levels based on proximity to areas such as residences, wetlands, fisheries, etc. While not an ARAR, the TMDL target concentration for PCBs in Big Spring Creek of 189 µg/kg is “To Be Considered” (Section 2.0). This concentration is based on the probable effects level developed by EPA (1997). DEQ’s TMDL report calls for the average Aroclor 1254 concentration to be less than 189 µg/kg. The TMDL target concentration would likely be met in the surface sediment after dredging in all subreaches under Alternative 3A. Under Alternative 3B, the TMDL target concentration would not be met in surface sediment in Subreaches 3B and 4B; however, it is expected that PCB concentrations would decrease over time since the upstream source would be removed and clean sediment would be transported through these subreaches. As shown in Table 16, conservative estimates of post-dredging 95% UCLs of mean PCB concentrations that consider mixing of deeper (undredged) sediment with surface sediment at some time in the future would slightly exceed the TMDL target concentration in Subreach 2A, and would meet the target in Subreaches 3B, 4A, and 4B. The TMDL target would not be met in Subreaches 2B and 3A; however, the UCLs in these subreaches are skewed by a small number of high PCB concentration samples.

The TMDL target concentration for PCBs in fish tissue (<0.025 mg/kg) would not likely be met in this alternative given the potential residual level of PCBs in sediment (69 µg/kg) based on observations from the pilot test. However, fish tissue PCB concentrations are expected to decrease, and potentially would fall below 0.12 mg/kg (site-specific risk assessment target), which would allow for some limited consumption of fish.

Six surface water samples were collected from Reaches 2, 3, and 4 of Big Spring Creek during the risk assessment (CDM, 2005), and PCBs were not detected in these samples. The detection limit for PCBs was less than the EPA drinking water maximum contaminant level (MCL) of 0.5 µg/L and the DEQ surface water criterion of 0.014 µg/L for protection of aquatic life. Therefore, contaminant-specific ARARS for PCBs are currently being met in surface water in Big Spring Creek. Contaminant-specific ARARs for surface water would need to be met during hydraulic dredging and would require monitoring.

Implementation of this alternative is expected to satisfy air quality regulations because disposal of PCB-impacted sediment in a solid waste landfill would stabilize contaminant sources and inhibit fugitive emissions.

Location-specific ARARs are expected to be met in the implementation of this alternative. Contacts with the appropriate agencies and acquisition of required permits related to streambeds, floodplains, and archaeological/paleontological resources would be completed.

DRAFT

Action-specific ARARs are expected to be met including the disposal requirements of TSCA and the hydrological regulations contained in the Strip and Underground Mine Reclamation Act. Dredging activities would require coordination with the Montana Fish, Wildlife, and Parks Department, The U.S. Army Corps of Engineers, the Montana Department of Natural Resources and Conservation, and possibly the Fergus County Conservation District. Revegetation requirements contained in the Surface Mining and Control Reclamation Act would be met. State of Montana air quality regulations related to dust suppression and control during construction activities would be met using water sprays where applicable, i.e. staging areas and haul roads with heavy vehicular traffic.

Occupational Safety and Health Administration (OSHA) requirements would be met by requiring appropriate safety training for all on-site workers during the construction phase. Site activities would be conducted under the guidance of a Health and Safety Plan for the site as per OSHA 29 CFR 1910.120. Site personnel would have completed 40-hour hazardous waste operations and emergency response training and would be current on the 8-hour annual refresher training as required by OSHA.

5.4.3 Long-Term Effectiveness and Permanence

This alternative would reduce contaminant mobility at the site by removing the most highly contaminated sediment and disposing of the waste in a permitted Class II landfill; however, not all contaminated sediment would be removed under Alternative 3. Remaining PCB-impacted sediment would be left in-place in the stream bed. PCB concentrations in fish tissue and other aquatic and terrestrial organisms are expected to be reduced; however, the degree of reduction would not be known until monitoring is completed after remediation has occurred. Reliable monitoring results to show reductions in PCBs in fish tissue would take several years to obtain. Rainbow and brown trout in the creek are currently impacted with PCBs. Therefore, it would take an estimated 6 to 8 years for new generations of fish that have not previously been impacted by PCBs to grow to the appropriate size for sampling and accurately reflect the post-remediation PCB concentrations in fish tissue. FWP protocols for monitoring fish in Big Spring Creek include the collection of rainbow trout (13-15 inches total length) and brown trout (14-16 inches total length).

The known sources of PCBs in paint associated with the hatchery raceways and other areas that may discharge to Big Spring Creek have been removed or encapsulated. Thus, reductions in the mass of PCBs in the stream are expected to be permanent. Since PCBs would remain in a portion of the stream sediment under this alternative, PCBs can still be mobilized and transported downstream, which reduces the long-term effectiveness when compared to alternatives with complete removal. Additionally, UCL calculations (Section 5.4.1) based on assumed residual PCB concentrations in dredged areas show that removal of PCBs from the upper six inches of sediment substantially reduces the 95% UCL of mean PCB concentrations even if the sediment in deeper zones mixes with sediment from the shallow layers.

After dewatering, the PCB-impacted stream sediment would be encapsulated in a permitted Class II landfill, which would effectively isolate this waste and reduce contaminant mobility. This alternative achieves long-term risk reduction by transporting the contaminated materials to a facility that specializes in the storage and disposal of non-hazardous wastes, thus ensuring the long-term permanence of the remedy. The portion of the impacted sediment that remains in the stream reduces the long-term effectiveness of this alternative compared to complete removal alternatives; however, the reduction in long-term effectiveness is at least partially offset by the

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reduced level of habitat destruction. Maintaining the stream habitat is important to the health of the stream and is supported by RAO No. 2 (Section 3.1.1) which calls for maintaining a healthy and diverse aquatic and riparian ecosystem.

5.4.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

Reduction of contaminant mobility is the primary objective of this alternative. The volume and toxicity of the contaminants in the waste materials would not be physically or chemically reduced. The partial removal of the impacted sediment from Big Spring Creek would reduce the contaminant mobility by moving a portion of the waste to a secure location. The waste materials would be encapsulated in an engineered landfill cell, which is protected from erosion and water infiltration. It is possible that PCBs could be remobilized from deeper in the streambed over time since a portion of the PCB-impacted sediment would be left in place. High flow conditions could cause scour and redeposition of PCB-impacted sediment that remains after hydraulic dredging is completed. However, the limited nature of the flow regime in Big Spring Creek (Section 1.2.4) is favorable for limiting scour and redeposition of sediment. The consistent flow from the Big Spring and flow attenuation from Hansen Creek dam tend to limit the amount of sediment transport and upstream sediment supply from tributaries to Big Spring Creek. The limited flow regime is supported by the PCB concentration data. Although stream sediment and fish tissue sampling have documented PCB impacts several miles downstream from the hatchery sources, the highest PCB concentrations are still observed in the area directly below each hatchery. This shows that contaminant mobility is naturally limited by the system; however, it is possible that fine-grained sediment from deeper layers could migrate via piping into the voids created by removal of the surface fines. Removal of PCBs from the upper layers of sediment would further limit the mobility of PCBs and supports the long-term effectiveness of this alternative with a small amount of habitat disturbance as compared to mechanical dredging, dry excavation, or complete removal by hydraulic dredging.

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5.4.5 Short-Term Effectiveness

5.4.5.1 General

It is anticipated that construction activities related to the implementation of this alternative would be completed in one construction season. Impacts associated with construction activities should not significantly impact human health.

Short term air quality impacts to the immediate environment may occur due to the relatively large volume of sediment removal. The wet nature of the sediment should control fugitive dust; however, dry sediment being stored prior to hauling to the landfill may require the use of water spray to control fugitive dust. The use of heavy equipment and haul trucks, and the need for haul roads, staging areas, and sediment processing areas would impact local residents in the project area during construction activities. Other short-term impacts to local residents would include potential noise and dust from construction activities. Noise can be controlled through the use of set working hours. Control of fugitive dust may require the use of water sprays.

On-site workers would be protected by following a site specific Health and Safety Plan, employing appropriate personal protective equipment, and by following proper operating and safety procedures. However, short term water quality impacts to the immediate environment may occur due to the suspension of sediment during dredging.

Impacts to the surrounding community are expected to be minimal due to the location of the project site. The most significant short-term impact to the surrounding community would involve increased vehicle traffic, particularly haul truck traffic, with associated safety hazards and potential dust generation. A traffic control plan, including warning signs and possibly flaggers, would be required while transporting these wastes.

5.4.5.2 Alternative 3A

Direct Effects on Biota. Under Alternative 3A, partial removal (upper 6-inches) via hydraulic dredging would be conducted in all subreaches of the upper creek. Hydraulic dredging is considered to be the least invasive and destructive alternative affecting aquatic life in the stream. Removing fine sediment from the upper 6-inches via hydraulic dredging from all subreaches would likely remove most of the periphyton, rooted aquatic plants, and invertebrates from the creek. As remediation moves downstream, most fish may be driven out of the upper creek to areas below the confluence with the East Fork, or they may move upstream past the dredging activities. Fish driven out of the remediated areas would compete for habitat and food with fish inhabiting the other sections of the creek and could result in reduced growth and even mortality depending on the resource availability and partitioning.

Direct adult and juvenile trout mortality should be low for these mobile organisms. Fish eggs and sac fry found in the gravels during dredging would likely have close to 100% mortality. Dredging time restrictions could minimize this loss. Surveys conducted on Big Spring Creek indicate brown trout spawn between mid-October and late November. Brown trout eggs hatch during the winter and the sac fry probably stay in the gravels until March. Spawning for rainbow trout likely runs from March through May, with swim-up (emergence from the gravels) occurring somewhere between early June and late July. If dredging is postponed until after trout swim-up in June or July, mortality of YOY rainbow trout should be reduced. It would take an estimated 8 months to dredge the entire 2.77 miles. If the dredging occurs all within one calendar year, then it would not be possible to avoid work during the spawning period for one or both trout species. If dredging were split between calendar years, it would be possible to avoid these critical time periods. Survival of eggs and fry could occur in the streambed cobbles of riffle crests that are not dredged to preserve stream stability. Use of Big Spring Creek above the East Fork by brown trout for spawning is limited, and it is therefore unlikely that reproduction from brown trout in this area provides much recruitment to rest of Big Spring Creek; dredging impacts to brown trout reproduction in this reach would likely have little impact on brown trout numbers in Big Spring Creek. Conversely, many more rainbow trout spawn in the two miles below the lower hatchery than do brown trout, and this may contribute substantially to the rainbow trout population in Big Spring Creek.

Recolonization. The length of time anticipated for recolonization of fish, invertebrates, rooted aquatic plants, and periphyton to the upper creek under Alternative 3A would likely be less than mechanical dredging or dry excavation alternatives because only the fines would be removed, leaving other habitat features in place. Unfortunately, the most impacted areas of the creek are near the source of the creek, leaving only two small tributaries (Hansen and Castle Creek) that would serve as an upstream source of plants and animals to assist in the recolonization of the dredged portion of the creek.

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Fish. Under this alternative, fish may be driven out of the upper section of the creek due to dredging activities. The length of time required to hydraulically dredge under this alternative may overlap the spawning period of both spring spawning rainbow trout and fall spawning brown trout. Brown trout redd counts conducted on Big Spring Creek below the East Fork since 2002 indicate brown trout spawn between mid-October and late November. Impacts to spawning fish likely extend beyond actual physical removal and destruction during dredging by reducing sediment stability until after a high flow period (Harvey and Lisle 1998). It may take several years for fines to re-deposit in the creek. Periphyton, rooted aquatic vegetation, and invertebrates should return to the remediated sections of the creek faster than other alternatives, allowing fish to more rapidly recolonize the remediated area of the creek.

Invertebrates. Under this alternative, invertebrates would be completely removed from the upper creek. This impact would be similar to what is seen following rotenone treatments used to kill fish from streams. In these studies, invertebrate communities, in terms of taxa richness and abundances, essentially returned to pre-treatment conditions within 2 years (Whelan 2002) although some recolonization was evident as soon as several months after the treatments. This same length of time for invertebrate recolonization would be anticipated under this alternative, although recolonization may occur faster than alternative 2 because less destroyed habitat and hydraulic features (pools, riffles) would need to be restored within the remediated area.

Aquatic Plants. Under this alternative, all aquatic plants and seed banks stored in the sediment would be completely removed from the upper creek. Upstream seed sources, albeit limited, would likely begin to re-establish aquatic plants within 2 years following completion of the project. Waterfowl activity and movement, prominent in the creek, may assist in spreading new seeds to the remediated areas. Even so, it may take several years for aquatic vegetation to return to conditions seen prior to dredging actions, although recolonization may occur faster than Alternative 2 because less habitat features would need to be restored within the remediated area.

Terrestrial Vegetation. Under this alternative, impacts to the woody plants on both streambanks along the entire length of the upper creek would be minimal, due to the fact that most activity would occur in-channel. Two situations would result in some damage: 1) where excavators are needed to lift and remove portable sediment control barriers; and 2) at the eight staging locations where access to and from the stream could cause damage to woody vegetation. Depending on the extent of damage, vegetation would regain original size and vigor in 2-5 years. The degree of damage under this alternative would be less than the mechanical dredging and dry excavation alternatives.

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5.4.5.3 Alternative 3B

Direct Effects on Biota. Under Alternative 3B, partial removals (upper 6-inches) via hydraulic dredging would be conducted in the upper 3 subreaches of the creek. Hydraulic dredging is considered to be the least invasive and destructive alternative affecting aquatic life in the stream. Removing fine sediment from the upper 6-inches via hydraulic dredging from the upper 3 subreaches would likely remove most of the periphyton, rooted aquatic plants, and invertebrates from those sections of the creek. As remediation moves downstream, fish may be driven out of the upper 3 subreaches, or they move upstream past the dredging activities. Fish driven out of the remediated areas would invariably compete for habitat and food with fish inhabiting the other sections of the creek and could result in reduced growth and even mortality depending on the resource availability and partitioning.

Direct adult and juvenile trout mortality should be low for these mobile organisms. Fish eggs and sac fry found in the gravel during dredging would likely have close to 100% mortality. Dredging time restrictions could minimize this loss. It would take an estimated 4 months to dredge the upper 3 subreaches, so there is potential that only a portion of the project area would be dredged during the critical spawning and rearing period. Surveys conducted on Big Spring Creek indicate brown trout spawn between mid-October and late November. Brown trout eggs hatch during the winter and the sac fry probably stay in the gravels until March. Spawning for rainbow trout likely runs from March through May, with swim-up (emergence from the gravels) occurring somewhere between early June and late July. If dredging is postponed until after trout swim-up in June or July, mortality of YOY rainbow trout should be reduced. Length of dredging time and seasonality of dredging may make such time restrictions impractical or require dredging over two seasons. Survival of eggs and fry could occur in the streambed cobbles of riffle crests that are not dredged to preserve stream stability. It is unlikely that reproduction from brown trout in the upper 2 miles of Big Spring Creek provides much recruitment to Big Spring Creek; dredging impacts to brown trout reproduction in this reach would likely have little impact on brown trout numbers in Big Spring Creek. However, rainbow trout spawning in the two miles below the lower hatchery may contribute substantially to the rainbow trout population in Big Spring Creek.

Recolonization. The length of time anticipated for recolonization of fish, invertebrates, rooted aquatic plants, and periphyton to the upper creek under Alternative 3B would likely be less than 3A because less area would be remediated. Unfortunately, the most impacted areas of the creek are near the source of the creek, leaving only two small tributaries (Hansen and Castle Creek) that would serve as an upstream source of plants and animals to assist in the recolonization of the dredged portion of the creek.

Fish. Under this alternative, fish may be driven out of the upper 3 subreaches of the creek due to dredging activities. The length of time required to hydraulically dredge under this alternative may overlap the spawning period of one or both spring spawning rainbow trout and fall spawning brown trout, but would be less than Alternative 3A. Impacts to spawning fish likely extend beyond actual physical removal and destruction during dredging by reducing sediment stability until after a high flow period (Harvey and Lisle 1998). It may take several years for fines to re-deposit in the creek. Periphyton, aquatic vegetation, and invertebrates should return to the remediated sections of the creek faster than Alternative 3A, allowing fish to more rapidly recolonize the remediated area of the creek.

Invertebrates. Under this alternative, invertebrates would be completely removed from the upper 3 subreaches of the creek. This impact would be similar to what is seen following rotenone treatments used to kill fish from streams. In these studies, invertebrate communities, both taxa richness and abundances, essentially returned to pre-treatment conditions within 2 years (Whelan 2002) although some recolonization was evident as soon as several months after the treatments. This same length of time for invertebrate recolonization would be anticipated under this alternative, although recolonization may occur faster than Alternative 3A because less area would be remediated.

Aquatic Plants. Under this alternative, all aquatic plants and seed banks stored in the sediment would be completely removed from the upper 3 subreaches of the creek. Upstream seed sources, albeit limited, would likely begin to re-establish aquatic plants within 2 years following completion of the project. Waterfowl activity and movement, prominent in the creek, may assist in spreading new seeds to the remediated areas. Even so, it may take several years

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for aquatic vegetation to return to conditions seen prior to dredging actions, although recolonization may occur faster than Alternative 3A because less area would be remediated.

Terrestrial Vegetation. Under this alternative, impacts to the woody plants on both streambanks along the entire length of the upper creek would be minimal, due to the fact that most activity would occur in-channel. Two situations would result in some damage: 1) where excavators are needed to lift and remove portable sediment control barriers; and 2) at the eight staging locations where access to and from the stream could cause damage to woody vegetation. Depending on the extent of damage, vegetation would regain original size and vigor in 2-5 years. The degree of damage under this alternative would be less than the mechanical dredging and dry excavation alternatives, and less than Alternative 3A because only the upper 1.25 miles of creek would be remediated.

5.4.6 Implementability

This alternative is both technically and administratively feasible. Dredging, sediment dewatering, water treatment, waste transportation and disposal, and stream restoration are readily implementable using commercially available equipment and materials. Key project components, such as the availability of equipment, construction expertise, and sufficient landfill space, are present and would aid in the timely implementation and successful execution of the proposed project. Permits that would be required include a Stream Protection Act 124 permit from FWP, a 318 permit (temporary exceedance of turbidity standards) from DEQ, and a general permit for storm water discharge from construction activity (any construction activity that disturbs more than one acre) would be required. A 404 permit from the U.S. Army Corps of Engineers would be required if replacement backfill material is placed in the streambed.

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5.4.7 Cost

The total present-worth cost for this alternative has been estimated at $2,839,575 for Alternative 3A and $1,586,593 for Alternative 3B. The assumptions used in estimating these costs are presented in Table 21. Table 22 and Table 23 present the cost details associated with implementing Alternative 3A and 3B, respectively. The total cost includes the present-worth value of 30 years of annual maintenance and monitoring costs in addition to capital costs.

Conceptual Design and Assumptions

Given the shallow depth and size of Big Spring Creek, it has been assumed that sediment would be removed using a 4- or 6-inch portable dredge. A 6-inch gravel dredge has the ability to pump sediment slurry a distance of up to 1,000 feet and a lift of up to 100 feet. A 4-inch dredge, while lighter and easier to move, has a shorter pumping distance (approximately 100 feet) and less lift (up to 10 feet). The dredge would be equipped with a suction hose with regulated nozzle that allows only sediment that is finer than 1/4-inch to be entrained in the dredge slurry. Although paint chips larger than 1/4 inch diameter have been observed in Big Spring Creek, it is assumed that the action of the dredge and the brittle nature of the paint chips would break the paint chips into smaller particles that can be recovered by the dredge. This phenomenon was observed in sediment samples that were shaken in sieves during the RI.

For the conceptual design and associated cost estimate, it is assumed that the dredge slurry is pumped into a series of 25-cubic yard filter boxes to dewater the sediment. The filter boxes are lined with a geotextile filter fabric to allow water to drain from the sediment. The water and suspended sediment would be collected from the bottom of the filter box and pumped to a settling tank for the first stage of water treatment. A flocculant, such as Chitosan, can be added to increase the settling velocity of fine particles and reduce the required holding time in the settling tank. A preliminary bench-scale test of Chitosan on fine sediment collected from Big Spring Creek indicated that suspended sediment rapidly settled with the addition of a Chitosan solution, while suspended sediment in a control sample without Chitosan did not rapidly settle.

After the initial treatment in a settling tank, the water can be treated through sand filters and, if necessary, a series of bag filters (i.e., 25, 5, and 1 micron filters) to "polish" the water prior to discharge into Big Spring creek. Both turbidity and PCBs would be monitored to verify compliance with the terms of the 318 permit issued by DEQ.

Sediment would remain in filter boxes until the free-draining liquids have been removed. After draining is completed, the sediment would be removed from the filter boxes and loaded into a haul truck for transportation to the landfill. The sediment would likely be disposed of at the Montana Waste Systems High Plains Landfill located in Great Falls, Montana.

Because sediment would only be removed from approximately the upper six inches of sediment, it has been assumed that the removal of the fine fraction (1/4-inch minus) would not cause significant stream instability. Particle size sampling conducted during the RI (Olympus, 2009) indicated approximately 42 percent of sediment by weight is finer than 1/4 inches. This percentage is based on a weighted average by area and geomorphic type. Therefore, less than half of the sediment in the upper 6 inches would be removed. Since the sediment would largely be removed from voids around cobbles and gravel particles, the drop in bed elevation should be less than 3 inches (half of the removal depth). If deeper sediment is removed from pools or other areas with large accumulations of fine-grained sediment, then the fines may need to be replaced.

Since the filter boxes, settling tanks, and filtration system components are relatively portable, it is assumed that the impact to property where dewatering and water treatment occurs would be relatively minor and would consist of small disturbances to grassy areas and the presence of tire tracks. These areas would be graded and reseeded as necessary to return the properties to pre-construction conditions.

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The general construction steps for implementing Alternative 3 are as follows:

- mobilization and setting up the dredging, dewatering, and water treatment equipment;
- prepare staging areas approximately every 2000 feet of stream (8 staging areas);
- removal of 1/4-inch minus sediment with a dredge;
- pumping dredge slurry to a collection area such as filter boxes;
- dewatering of sediment so that free-draining liquids are removed;
- collection and treatment of water and suspended sediment from the dewatering operation;
- monitoring of PCB concentrations and turbidity levels in the treated water;

- discharge of treated water to Big Spring Creek;
- collection and loading of dewatered sediment into trucks and hauling to the landfill;
- removal and reclamation of haul roads, and temporary sediment staging, storage, and treatment areas; and
- re-establishing vegetation in disturbed areas.

Hydraulic dredging via plain suction dredge offers the following advantages over other technologies:

- suction dredging is a “surgical” removal procedure compared to mechanical dredging and dry excavation;
- low-impact to the hydraulic stability and biota of the stream compared to mechanical dredging and dry excavation;
- allows for the segregation and removal of fine particles only (1/4-inch minus);
- no screening or sorting of the sediment is required;
- leaves gravel and cobbles in stream;
- suitable for shallow removal; and
- plain suction dredging has less potential for resuspension of sediment than mechanical dredging;

DRAFT

Disadvantages of hydraulic dredging with a plain suction dredge include:

- dredge slurry has a high water content and low solids content;
- the removal depth is limited unless a cutterhead is used;
- extensive dewatering of sediment is required compared to mechanical dredging and dry excavation;
- the large dewatering volume requires treatment and handling of a large volume of water; and
- resuspension of contaminants is possible.

5.5 Alternative 4: Partial Removal of PCB-Impacted Stream Sediment Via Dry Excavation with Disposal at a Solid Waste Landfill

The remediation strategy for Alternative 4 involves partial removal of PCB-impacted stream sediment via dry excavation. Dry excavation involves temporarily rerouting the stream from its existing channel to allow the excavation of contaminated sediment in the absence of flowing water. A diversion or series of diversions would be used to reroute the flow in Big Spring Creek while contaminated sediment is excavated and removed from the streambed. The diversions could include pumping and piping, use of a siphon, excavation of a temporary diversion channel, or a combination of these technologies.

Two partial removal scenarios are considered under Alternative 4. Alternative 4A considers the removal of sediment from the upper 6 inches from Subreaches 2A through 4B. Alternative 4B considers the removal of the upper 6 inches of sediment from Subreaches 2A, 2B, and 3A. The rationale for these removal scenarios is presented in Section 5.1. Under Alternative 4B, Subreaches 3B, 4A, and 4B would be monitored according to MNR procedures since remediation would not occur in these areas.

Partial removal would involve sediment being excavated from the stream bed to a depth of approximately 6 inches using conventional equipment such as a hydraulic excavator after the stream is diverted. The 6-inch excavation depth is likely to be variable and would be controlled by the size of the larger particles. For example, if the dominant particle size in a given area of the stream is 1 foot, excavation to a depth of only 6-inches is nearly impossible. The excavated material would be loaded onto haul trucks and transported to temporary staging and containment areas for dewatering and processing. The sediment would be screened to remove oversized material (>1/4-inch) that is not likely to be contaminated. The segregated oversized sediment would be returned to the creek. After screening and dewatering, the fine sediment would be transported via truck to a permitted Class II municipal solid waste landfill for disposal. Water collected in the dewatering process would be treated to remove turbidity and PCBs in suspended sediment and discharged into Big Spring Creek. Dry excavation would alter the streambed so extensive stream restoration construction would be required.

5.5.1 Overall Protection of Human Health and the Environment

As shown in the human health risk assessments (CDM, 2005, 2008, and 2009), the only significant risk to human health is the consumption of PCB-impacted fish. Risks to human health from exposure via direct contact or ingestion of stream sediment and direct contact or ingestion of stream water were not significant.

The implementation of this alternative would provide a means of reducing the risk to both human health and the environment. Partial removal of PCB-impacted sediment, particularly removal of sediment from areas with the highest concentration of PCBs, would reduce the degree of exposure to both aquatic organisms and terrestrial organisms that feed on aquatic organisms. The risk to human health from consumption of PCB-impacted fish would also be reduced accordingly. However, partial removal would leave some PCB-impacted sediment in place so the exposure pathway would be reduced, but not eliminated. Therefore, exposure of aquatic organisms to PCBs, while reduced, would still exist. Similarly, the exposure of terrestrial organisms that feed on aquatic organisms would be reduced compared to the no action alternative, but would still exist. Human exposure to PCBs from consumption of fish would be reduced under this alternative, but would still exist. Institutional controls, such as fish consumption advisories and catch and release only fishing regulations, will remain in effect at the Site until it is demonstrated that PCBs in fish tissue are at concentrations that are safe for human consumption.

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Alternative 4A

The degree of risk reduction is difficult to quantify because of the high variability of the PCBs in stream sediment data, the variability in the fish tissue/stream sediment relationship, and in estimating the post-excavation residual PCB in sediment concentrations. To estimate the degree of risk reduction under Alternative 4A, assumptions have been made about post-remediation residual PCB concentrations, and mean PCB concentrations and 95% UCLs of mean PCB concentrations have been calculated for these conditions and compared to the existing (pre-excavation) mean and 95% UCL to evaluate risk reduction. The 95% UCLs were calculated using EPA's ProUCL statistical software package (EPA, 2007a and 2007b). The pre-excavation mean PCB concentrations are shown in Table 16, and range from 4,785 µg/kg in Subreach 2A to 52.56 in Subreach 4A. The pre-excavation 95% UCLs of mean PCB concentrations are shown in Table 16, and range from 6,761 µg/kg in Subreach 2A to 106.9 µg/kg in Subreach 4A. ProUCL calculations are presented in Appendix G.

Three conditions have been evaluated for post-excavation PCB concentrations in stream sediment (0, 69, and 100 µg/kg in order to test the sensitivity of the model to effectiveness of PCB removal). The estimated residual PCB concentrations for the first condition were based on an data from the suction dredge pilot test (Section 1.2.7). The quantity of paint chips found in five post-dredging core samples was an average 0.017% (i.e., 0.00017 mg paint per mg sediment). Laboratory analyses of PCB concentrations in three paint chips samples from the Phase 2 particle size sampling yielded results of 339, 404, and 480 µg/kg for an average of 408 µg/kg. Applying the quantity of paint chips and the average PCB concentration in paint chips yields an estimated post-dredging PCB concentration of 69 µg/kg in stream sediment. Although this residual concentration was developed from suction dredging data, it is reasonable that similar residual concentrations would be observed from dry excavation dredging. This condition was modeled by substituting PCB concentrations of 69 µg/kg (the typical lower detection limit achieved during the Phase 1 RI sampling) for each sample in depth intervals H1 and H2 of the Herrera stream sediment data and recalculating the 95% UCL by subreach. For conservatism, this calculation combined all four depth intervals in a given subreach to simulate the condition that PCBs from depth intervals H3 and H4 are mixed with the remediated sediments in H1 and H2 at some point in the future. This condition could occur through mixing of sediment via scour and deposition or from migration of fines toward the surface via piping (i.e., the migration of fine-grained sediment into the voids created by removal of the fine sediment in the upper 6-inch of sediment). The results of the 95% UCL calculations are presented in Table 16, and the results are compared to the pre-excavation 95% UCL. The 95% UCLs of mean PCB concentrations by subreach and the percent the UCL would be reduced by dry excavation are as follows:

- Subreach 2A - 218.8 µg/kg (96.8% reduction)
- Subreach 2B - 615.1 µg/kg (6.4% reduction)
- Subreach 3A - 703.3 µg/kg (69.6% reduction)
- Subreach 3B - 151.2 µg/kg (29.5% reduction)
- Subreach 4A - 96.28 µg/kg (9.9% reduction)
- Subreach 4B - 73.98 µg/kg (57.5% reduction)

Mean PCB concentrations in each subreach were also calculated and are presented in Table 16. The mean PCB concentrations by subreach and the percent the mean would be reduced by mechanical dredging are as follows:

- Subreach 2A - 117.5 µg/kg (97.5% reduction)
- Subreach 2B - 174.3 µg/kg (17.3% reduction)

DRAFT

- Subreach 3A - 219.5 µg/kg (76.0% reduction)
- Subreach 3B - 76.01 µg/kg (26.5% reduction)
- Subreach 4A - 58.12 µg/kg (approximately zero)
- Subreach 4B - 62.72 µg/kg (20.2% reduction)

As described in the RI (Olympus, 2009), UCL calculations can be influenced by potential outliers. The post-excavation UCLs in Subreaches 2B and 3A appear to be skewed by a small number of high PCB concentrations. Out of 79 samples in Subreach 2B, only two samples (8,000 and 930 µg/kg) have concentrations greater than the 95% UCL of 615.1 µg/kg. Similarly, of 104 samples in Subreach 3A, only three samples (9,400, 6,900, and 720 µg/kg) have concentrations greater than the 95% UCL of 703.3 µg/kg. Compared to the pre-excavation 95% UCLs of mean PCB concentrations, the post-excavation UCLs are significantly reduced. With the exception of Subreaches 2B and 3A, which are skewed by a small number of high PCB concentration samples, the 95% UCL of mean PCB concentrations in the remaining subreaches are near or below the TMDL provisional target concentration of 189 µg/kg. PCB concentrations in the upper six inches, where aquatic organisms would have a greater likelihood of exposure, would have much lower PCB concentrations. Based on mean PCB concentrations, the only subreach that would not meet the TMDL target concentration of 189 µg/kg is Subreach 3A, which would have a residual mean PCB concentration of 219.5 based on the conservative assumption of complete mixing of the surface and subsurface sediment. Additionally, the estimated residual PCB concentration of 69 µg/kg is likely high because the short duration of the pilot test and the limited number of samples.

The use of the 95% UCL of mean PCB concentrations by subreach to estimate residual PCB concentrations as outlined above is probably conservatively high. Flow events large enough to cause scour and deposition of the deeper sediment would likely move sediment downstream, where it would be dispersed and diluted by mixing with “cleaner” downstream sediment. However, the contaminant fate and transport evaluation (Section 1.2.4) indicates that sediment transport is limited by the flow regime and sediment supply in upper Big Spring Creek.

The second (estimated low residual PCB concentrations) and third (estimated high residual PCB concentrations) conditions evaluated for post-excavation PCB concentrations are variations of the first condition with different residual PCB concentrations in the excavated areas. The results of these evaluations were used to complete a sensitivity analysis of post-remediation 95% UCL calculations. The fish/sediment relationship developed by FWP (Section 1.2.4) indicated that PCB concentrations in stream sediment would likely need to be less than typical analytical detection limits in order to allow for unlimited consumption of fish. Therefore, residual PCB concentrations of zero µg/kg were used for the second condition to estimate a lower bound on the post-remediation 95% UCL of mean PCB concentrations if sediment from deeper layers is mixed with surface sediment. It should be noted that PCB concentrations of zero µg/kg are not measurable because laboratory analytical methods are limited to the lower detection limit, which is always greater than zero. The third condition considered a post-remediation residual concentration of 100 µg/kg in excavated areas, which represents an estimated high-end for post-remediation conditions in the excavated areas. The sensitivity analysis for post-remediation 95% UCL calculations is presented in Table 17. The 95% UCLs calculated with zero µg/kg residual PCBs ranged from 63.4% to 95.4% of the 95% UCLs calculated with 69 µg/kg of residual PCBs. The 95% UCLs calculated with 100 µg/kg of residual PCBs ranged from 102.1% to 150% of the 95% UCLs calculated with 69 µg/kg of residual PCBs. The larger 95% UCLs generally had the smallest percent changes (relative to 69 µg/kg residual PCB concentrations), while the smallest 95% UCLs had the largest percent changes. For example, a fivefold increase (20 to 100 µg/kg) residual PCB concentration resulted in a 2 to

DRAFT

3 percent increase in 95% UCL for the larger UCL values. Although the smaller 95% UCL values showed a larger percent increase, these values are generally less than the TMDL target concentration and are of much less concern than the larger UCL values. Similarly, decreasing the residual PCB concentrations to zero µg/kg resulted in less than a 5 percent decreased the 95% UCLs for the larger UCL values. Thus, the sensitivity analyses show that the 95% UCL calculations are not very sensitive to the assumed residual PCB concentration.

Alternative 4B

The reduction in mean and 95% UCL of mean PCB concentrations by subreach for Alternative 4B was evaluated using the same procedure described above for Alternative 4A. Under Alternative 4B, sediment would be removed from Subreaches 2A, 2B, and 3A using dry excavation. Based on the results of the sensitivity analyses completed for Alternative 4A, the assumption used for post-excavation residual PCB concentrations (69 µg/kg) appears reasonable and neither increases (100 µg/kg) nor decreases (zero µg/kg) in this assumed value had a large impact on the results of the 95% UCL calculation for the larger UCL values. Therefore, the evaluation for Alternative 4B was completed using a post-excavation residual PCB concentration of 20 µg/kg. As shown in Table 16, the three highest pre-excavation 95% UCLs of mean PCB concentrations (657.2, 2,315, and 6,761 µg/kg) are from Subreaches 2A, 2B, and 3A, which supports the selection of these subreaches for removal under Alternative 4B.

The results of the mean and 95% UCL calculations are presented in Table 16, and the results are compared to the pre-excavation 95% UCL. The 95% UCLs of mean PCB concentrations by subreach and the percent the UCL would be reduced by dry excavation are as follows:

- Subreach 2A - 218.8 µg/kg (96.8% reduction)
- Subreach 2B - 615.1 µg/kg (6.4% reduction)
- Subreach 3A - 703.3 µg/kg (69.6% reduction)
- Subreach 3B – 214.5 µg/kg (0% reduction)
- Subreach 4A – 106.9 µg/kg (0% reduction)
- Subreach 4B – 174.2 µg/kg (0% reduction)

The mean PCB concentrations by subreach and the percent the mean would be reduced by mechanical dredging are as follows:

- Subreach 2A - 117.5 µg/kg (97.5% reduction)
- Subreach 2B - 174.3 µg/kg (17.3% reduction)
- Subreach 3A - 219.5 µg/kg (76.0% reduction)
- Subreach 3B - 103.4 µg/kg (0% reduction)
- Subreach 4A - 52.56 µg/kg (0% reduction)
- Subreach 4B - 78.61 µg/kg (0% reduction)

As was previously concluded for Alternative 4A, the post-excavation UCLs in Subreaches 2B and 3A appear to be skewed by a small number of high PCB concentrations. With the exception of Subreaches 2B and 3A, the 95% UCL of mean PCB concentrations in the remaining subreaches are near or below the TMDL provisional target concentration of 189 µg/kg. PCB concentrations in the upper six inches, where aquatic organisms would have a greater likelihood of exposure, would have much lower PCB concentrations. Based on mean PCB concentrations, the only subreach that would not meet the TMDL target concentration of 189 µg/kg is Subreach 3A, which would have a residual mean PCB concentration of 219.5

DRAFT

based on the conservative assumption of complete mixing of the surface and subsurface sediment. Additionally, the estimated residual PCB concentration of 69 µg/kg is likely high because the short duration of the pilot test and the limited number of samples.

The use of the 95% UCL of mean PCB concentrations by subreach to estimate residual PCB concentrations as outlined above is probably conservatively high. Flow events large enough to cause scour and deposition of the deeper sediment would likely also move sediment downstream, where it would be dispersed and diluted by mixing with “cleaner” downstream sediment.

5.5.2 Compliance With ARARs

A comprehensive list of federal and state ARARs is presented in Section 2.0 and Appendix E. ARARs are divided into contaminant-specific, location-specific, and action-specific requirements.

There are no state contaminant-specific ARARs for PCBs in stream sediment. Under the assumptions of the dry excavation conditions described above for Alternative 4, the 95% UCL of mean PCB concentrations in sediment (Table 16) would meet the federal chemical-specific ARAR-based PRG of 1 mg/kg (1,000 µg/kg) for PCB remediation waste in high occupancy areas (see Section 3.1.2.1) under both Alternatives 4A and 4B; however, it should be noted that the EPA regional administrator may also require cleanup to more stringent levels based on proximity to areas such as residences, wetlands, fisheries, etc. While not an ARAR, the TMDL target concentration for PCBs in Big Spring Creek of 189 µg/kg is “To Be Considered” (Section 2.0). This concentration is based on the probable effects level developed by EPA (1997). DEQ’s TMDL report calls for the average Aroclor 1254 concentration to be less than 189 µg/kg. The TMDL target concentration would likely be met in the surface sediment after dry excavation in all subreaches under Alternative 3A. Under Alternative 3B, the TMDL target concentration would not be met in surface sediment in Subreaches 3B and 4B; however, it is expected that PCB concentrations would decrease over time since the upstream source would be removed and clean sediment would be transported through these subreaches. As shown in Table 16, conservative estimates of post-excavation 95% UCLs of mean PCB concentrations that consider mixing of deeper (unexcavated) sediment with surface sediment at some time in the future would slightly exceed the TMDL target concentration in Subreach 2A, and would meet the target in Subreaches 3B, 4A, and 4B. The TMDL target would not be met in Subreaches 2B and 3A; however, the UCLs in these subreaches are skewed by a small number of high PCB concentration samples.

The TMDL target concentration for PCBs in fish tissue (<0.025 mg/kg) would not likely be met in this alternative given the potential residual level of PCBs in sediment (69 µg/kg) based on observations from the pilot test. However, fish tissue PCB concentrations are expected to decrease, and potentially would fall below 0.12 mg/kg (site-specific risk assessment target), which would allow for some limited consumption of fish.

Six surface water samples were collected from Reaches 2, 3, and 4 of Big Spring Creek during the risk assessment (CDM, 2005), and PCBs were not detected in these samples. The detection limit for PCBs was less than the EPA drinking water maximum contaminant level (MCL) of 0.5 µg/L and the DEQ surface water criterion of 0.014 µg/L for protection of aquatic life. Therefore, contaminant-specific ARARS for PCBs are currently being met in surface water in Big Spring Creek.

DRAFT

Implementation of this alternative is expected to satisfy air quality regulations because disposal of PCB-impacted sediment in a solid waste landfill would stabilize contaminant sources and inhibit fugitive emissions.

Location-specific ARARs are expected to be met in the implementation of this alternative. Contacts with the appropriate agencies and acquisition of required permits related to streambeds, floodplains, and archaeological/paleontological resources would be completed.

Action-specific ARARs are expected to be met including the disposal requirements of TSCA and the hydrological regulations contained in the Strip and Underground Mine Reclamation Act. Temporary stream diversion and in-stream excavation activities would require coordination with the Montana Fish, Wildlife, and Parks Department, The U.S. Army Corps of Engineers, the Montana Department of Natural Resources and Conservation, and possibly the Fergus County Conservation District. Revegetation requirements contained in the Surface Mining and Control Reclamation Act would be met. State of Montana air quality regulations related to dust suppression and control during construction activities would be met using water sprays where applicable, i.e. staging areas and haul roads with heavy vehicular traffic.

Occupational Safety and Health Administration (OSHA) requirements would be met by requiring appropriate safety training for all on-site workers during the construction phase. Site activities would be conducted under the guidance of a Health and Safety Plan for the site as per OSHA 29 CFR 1910.120. Site personnel would have completed 40-hour hazardous waste operations and emergency response training and would be current on the 8-hour annual refresher training as required by OSHA.

5.5.3 Long-Term Effectiveness and Permanence

This alternative would reduce contaminant mobility at the site by removing the most highly contaminated sediment and disposing of the waste in a permitted Class II landfill; however, not all contaminated sediment would be removed under Alternative 4. Remaining PCB-impacted sediment would be left in-place in the stream bed. PCB concentrations in fish tissue and other aquatic and terrestrial organisms are expected to be reduced; however, the degree of reduction would not be known until monitoring is completed after remediation has occurred. Reliable monitoring results to show reductions in PCBs in fish tissue would take several years to obtain. Rainbow and brown trout in the creek are currently impacted with PCBs. Therefore, it would take an estimated 6 to 8 years for new generations of fish that have not previously been impacted by PCBs to grow to the appropriate size for sampling and accurately reflect the post-remediation PCB concentrations in fish tissue. FWP protocols for monitoring fish in Big Spring Creek include the collection of rainbow trout (13-15 inches total length) and brown trout (14-16 inches total length).

The known sources of PCBs in paint associated with the hatchery raceways and other areas that may discharge to Big Spring Creek have been removed or encapsulated. Thus, reductions in the mass of PCBs in the stream are expected to be permanent. Since PCBs would remain in a portion of the stream sediment under this alternative, PCBs can still be mobilized and transported downstream, which reduces the long-term effectiveness when compared to alternatives with complete removal. Additionally, UCL calculations (Section 5.5.1) based on assumed residual PCB concentrations in excavated areas show that removal of PCBs from the upper six inches of sediment substantially reduces the 95% UCL of mean PCB concentrations even if the sediment in deeper zones mix with sediment from the shallow layers.

DRAFT

After dewatering, the PCB-impacted stream sediment would be encapsulated in a permitted Class II landfill, which would effectively isolate this waste and reduce contaminant mobility. This alternative achieves long-term risk reduction by transporting the contaminated materials to a facility that specializes in the storage and disposal of non-hazardous wastes, thus ensuring the long-term permanence of the remedy. The portion of the impacted sediment that remains in the stream reduces the long-term effectiveness of this alternative compared to complete removal alternatives. Although the degree of habitat destruction from Alternative 4 would be less than the complete removal alternatives, sediment of all sizes would still be removed from the upper 6 inches of the stream bed. The sediment would be screened, sorted, and the oversize material replaced into the stream. This would require extensive stream reconstruction to restore the geomorphic and habitat features of the stream.

5.5.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

Reduction of contaminant mobility is the primary objective of this alternative. The volume and toxicity of the contaminants in the waste materials would not be physically or chemically reduced. The partial removal of the impacted sediment from Big Spring Creek would reduce the contaminant mobility by moving a portion of the waste to a secure location. The waste materials would be encapsulated in an engineered landfill cell, which is protected from erosion and water infiltration. It is possible that PCBs could be remobilized from deeper in the streambed over time since a portion of the PCB-impacted sediment would be left in place. High flow conditions could cause scour and redeposition of PCB-impacted sediment that remains after dry excavation is completed. However, the limited nature of the flow regime in Big Spring Creek (Section 1.2.4) is favorable for limiting scour and redeposition of sediment. The consistent flow from the Big Spring and flow attenuation from Hansen Creek dam tend to limit the amount of sediment transport and upstream sediment supply from tributaries to Big Spring Creek. The limited flow regime is supported by the PCB concentration data. Although stream sediment and fish tissue sampling have documented PCB impacts several miles downstream from the hatchery sources, the highest PCB concentrations are still observed in the area directly below each hatchery. This shows that contaminant mobility is naturally limited by the system. Removal of PCBs from the upper layers of sediment would further limit the mobility of PCBs and supports the long-term effectiveness of this alternative with a lesser amount of habitat disturbance compared to the complete removal alternatives.

DRAFT

5.5.5 Short-Term Effectiveness

5.5.5.1 General

It is anticipated that construction activities related to the implementation of this alternative would be completed in one construction season. Impacts associated with construction activities should not significantly impact human health or the environment. On-site workers would be protected by following a site-specific Health and Safety Plan, employing appropriate personal protective equipment and by following proper operating and safety procedures. Short term water quality impacts may occur during installation of stream diversions; however, the use of dry excavation techniques would minimize these impacts compared to both mechanical and hydraulic dredging. Best management practices would be used to control erosion and sedimentation during the remedial action.

The use of a diversion to facilitate dry excavation has an increase short-term risk of localized flooding. In the event that the diversion fails (i.e., a pump, piping, or diversion berm fails) or the diversion is overtopped during a storm, there is a risk that localized flooding could occur. The risk can be reduced through the use of proper engineering design, and maintenance and monitoring of the diversion system.

Short term air quality impacts to the immediate environment may occur due to the relatively large volume of waste excavation and hauling. The wet nature of the sediment should control fugitive dust; however, dry sediment being stored prior to hauling to the landfill may require the use of water spray to control fugitive dust. The use of heavy equipment and haul trucks, and the need for haul roads, staging areas, and sediment processing areas would impact local residents in the project area during construction activities. Other short-term impacts to local residents would include potential noise and dust from construction activities. Noise can be controlled through the use of set working hours; however, if pumping is selected as the preferred option for diverting water, pumps would be required to operate 24 hours per day. Control of fugitive dust may require the use of water sprays.

On-site workers would be protected by following a site specific Health and Safety Plan, employing appropriate personal protective equipment, and by following proper operating and safety procedures. However, short term air quality impacts to the immediate environment may occur due to the relatively large volume of waste excavation and hauling. Control of fugitive dust may require the use of water sprays.

Impacts to the surrounding community are expected to be minimal due to the location of the project site. The most significant short-term impact to the surrounding community would involve increased vehicle traffic, particularly haul truck traffic, with associated safety hazards and potential dust generation. A traffic control plan, including warning signs and possibly flaggers, would be required while transporting these wastes.

DRAFT

5.5.5.2 Alternative 4A

Direct Effects on Biota. Under Alternative 4A, partial removal (upper 6-inches) via dry excavation would be conducted in all subreaches of the upper creek. Dry excavation is considered to be the second most invasive and destructive alternative affecting aquatic life in the stream only next to mechanical dredging. Removing the upper 6-inches via dry excavation from all subreaches would likely remove all periphyton, rooted aquatic plants, and invertebrates from the creek. Under this alternative, fish would be driven out of the upper section of the creek due to diversion and dewatering of the creek to facilitate dry excavation activities. Fish driven out of the remediated areas would compete for habitat and food with fish inhabiting the other sections of the creek and could result in reduced growth and even mortality depending on the resource availability and partitioning.

Direct adult and juvenile trout mortality should be low for these mobile organisms. Fish eggs and sac fry found in the gravel during excavation would likely have close to 100% mortality. Excavation time restrictions could minimize this loss. It would take an estimated 2 months to excavate the entire 2.77 miles, so there is potential that none of the project area would be excavated during the critical spawning and rearing periods. Surveys conducted on Big Spring Creek indicate brown trout spawn between mid-October and late November. Brown trout eggs hatch during the winter and the sac fry probably stay in the gravels until March. Spawning for rainbow trout likely runs from March through May, with swim-up (emergence from the gravels) occurring somewhere between early June and late July. If excavation is postponed until after trout swim-up in June or July, mortality of YOY rainbow trout should be reduced. Survival of eggs and fry would not likely occur in the streambed cobbles of riffle crests that are not excavated to preserve stream stability because these areas would be dry during operations. Length of excavation time and seasonality of excavation may make such time restrictions impractical or require excavation over two seasons. It is unlikely that reproduction from brown trout in the upper 2.77 miles of Big Spring Creek provides much recruitment to Big Spring Creek; excavation impacts to brown trout reproduction in this reach would likely have little impact on brown trout numbers in Big Spring Creek. However, rainbow trout spawning in the two miles below the lower hatchery may contribute substantially to the rainbow trout population in Big Spring Creek.

Recolonization. The length of time anticipated for recolonization of fish, invertebrates, rooted aquatic plants, and periphyton to the upper creek under Alternative 4A would likely be long compared with all other alternatives. Unfortunately, he most impacted areas of the creek are near the source of the creek, leaving only two small tributaries (Hansen and Castle Creek) that would serve as an upstream source of plants and animals to assist in the recolonization of the excavated portion of the creek.

Fish. Under this alternative, fish would be driven out of the upper section of the creek due to diversion and dewatering of the creek to facilitate dry excavation activities. The length of time required to dry excavate under this alternative may overlap the spawning period of either spring spawning rainbow trout or fall spawning brown trout. Brown trout redd counts conducted on Big Spring Creek below the East Fork since 2002 indicate brown trout spawn between mid-October and late November. Impacts to spawning fish likely extend beyond actual physical removal and destruction during dry excavation by reducing sediment stability until after a high flow period (Harvey and Lisle 1998). Substrate within the creek would have to be re-graded and constructed, so it may take several years for the periphyton, aquatic vegetation, and invertebrates to return to the remediated sections of the creek that would allow fish to recolonize the area in any significant numbers.

Brewery Flats Case Study. From 1998 – 2000, a 2,600-foot reach of Big Spring Creek was constructed. It replaced an entrenched “ditch” with a meandering riffle pool stream channel and floodplain. At Brewery Flats, a new artificial gravel bottomed channel was constructed in the dry with a more natural meander pattern. The excavated area on upper Big Spring Creek would not be a new channel. However, the Brewery Flats project can be used to represent how quickly an area depauperate of insects and plants can become home to Big Spring Creek trout. Within one-year, adult trout numbers were higher than the 6-year average prior to the project. Adult trout density (≥ 10 inches) increased by 41% and total biomass by 79% in the six years immediately after the project compared to the six previous years. However, small rainbow trout (6 – 9.9 inches) declined by 59% per mile after the project was completed (Tews, 2007).

Any alternative that does not have long lasting impacts on stream stability should only have short-term impacts to the trout population. Based on the Brewery Flats example, these impacts could be very short-lived. Less than 10% of Big Spring Creek would be excavated during this project. High trout numbers, and fish displaced downstream, would likely repopulate the upper creek shortly after the project is completed. The risk assessment indicated that risks to trout were insignificant to very low (CDM, 2008).

Invertebrates. Under this alternative, invertebrates would be completely removed from the upper creek. This impact would be similar to what is seen following rotenone treatments used

DRAFT

to kill fish from streams. In these studies, invertebrate communities, both taxa richness and abundances, essentially returned to pre-treatment conditions within 2 years (Whelan 2002) although some recolonization was evident as soon as several months after the treatments. This same length of time for invertebrate recolonization would be anticipated under this alternative.

Aquatic Plants. Under this alternative, all aquatic plants and seed banks stored in the sediment would be completely removed from the upper creek. Upstream seed sources, albeit limited, would likely begin to re-establish aquatic plants within 2 years following completion of the project. Waterfowl activity and movement, prominent in the creek, may assist in spreading new seeds to the remediated areas. Even so, it may take several years for aquatic vegetation to return to conditions seen prior to excavation actions.

Terrestrial Vegetation. Under this alternative, impacts to the woody plants on both streambanks along the entire length of the upper creek would be damaged or removed due to the need for excavator operators to have adequate range of motion for activities and unimpeded view of the stream. Depending on the extent of damage, vegetation would regain original size and vigor in 2-5 years. The degree of damage under this alternative would be less than the mechanical dredging alternatives, due to the ability of the excavators to conduct some work in the dry stream channel. Impacts would still be greater than with hydraulic dredging.

5.5.5.3 Alternative 4B

Direct Effects on Biota. Under Alternative 4B, partial removal (upper 6-inches) via dry excavation would be conducted in the upper 3 subreaches of the creek. Dry excavation is considered to be the second most invasive and destructive alternative affecting aquatic life in the stream only next to mechanical dredging. Removing the upper 6-inches via dry excavation from the upper 3 subreaches would invariably remove all periphyton, aquatic plants, and invertebrates from the creek. Under this alternative, fish would be driven out of the upper section of the creek due to diversion and dewatering of the creek to facilitate dry excavation activities. Fish driven out of the remediated areas would invariably compete for habitat and food with fish inhabiting the other sections of the creek and could result in reduced growth and even mortality depending on the resource availability and partitioning.

Direct adult and juvenile trout mortality should be low for these mobile organisms. Fish eggs and sac fry found in the gravel during excavation would likely have close to 100% mortality. Excavation time restrictions could minimize this loss. It would take and estimated one month to excavate the upper 3 subreaches of the creek, so likely that none of the project area would be excavated during the critical spawning and rearing period. Surveys conducted on Big Spring Creek indicate brown trout spawn between mid-October and late November. Brown trout eggs hatch during the winter and the sac fry probably stay in the gravels until March. Spawning for rainbow trout likely runs from March through May, with swim-up (emergence from the gravels) occurring somewhere between early June and late July. Survival of eggs and fry would not likely occur in the streambed cobbles of riffle crests that are not excavated to preserve stream stability because these areas would be dry during operations. If excavation is postponed until after trout swim-up in June or July, mortality of YOY rainbow trout should be reduced. Length of excavation time and seasonality of excavation may make such time restrictions impractical or require dredging over two seasons. It is unlikely that reproduction from brown trout in the upper 1.25 miles of Big Spring Creek provides much recruitment to Big Spring Creek; excavation impacts to brown trout reproduction in this reach would likely have little impact on brown trout

DRAFT

numbers in Big Spring Creek. However, rainbow trout spawning in the two miles below the lower hatchery may contribute substantially to the rainbow trout population in Big Spring Creek.

Recolonization. The length of time anticipated for recolonization of fish, invertebrates, rooted aquatic plants, and periphyton to the upper creek under alternative 4B would likely be long compared with he hydraulic dredging alternatives (3A and 3B) but could be shorter than 4A since only the upper 3 subreaches would be remediated. Unfortunately, the most impacted areas of the creek are near the source of the creek, leaving only two small tributaries (Hansen and Castle Creek) that would serve as an upstream source of plants and animals to assist in the recolonization of the excavated portion of the creek.

Fish. Under this alternative, fish would be driven out of the upper 3 subreaches of the creek due to diversion and dewatering of the creek to facilitate dry excavation activities. The length of time required to dry excavate under this alternative would not likely overlap the spawning period of spring spawning rainbow trout and fall spawning brown trout. Impacts to spawning fish likely extend beyond actual physical removal and destruction during dry excavation by reducing sediment stability until after a high flow period (Harvey and Lisle 1998). Substrate within the creek with have to be re-graded and constructed, so it may take several years for the periphyton, aquatic vegetation, and invertebrates to return to the remediated sections of the creek that would allow fish to recolonize the area in any significant numbers.

Brewery Flats Case Study. From 1998 – 2000, a 2600-foot reach of Big Spring Creek was constructed. It replaced an entrenched “ditch” with a meandering riffle pool stream channel and floodplain. At Brewery Flats, a new artificial gravel bottomed channel was constructed in the dry with a more natural meander pattern. The excavated area on upper Big Spring Creek would not be a new channel. However, the Brewery Flats project can be used to represent how quickly an area depauperate of insects and plants can become home to Big Spring Creek trout. Within one-year adult trout numbers were higher than the 6-year average prior to the project. Adult trout density (≥ 10 inches) increased by 41% and total biomass by 79% in the six years immediately after the project compared to the six previous years. However, small rainbow trout (6 – 9.9 inches) declined by 59% per mile after the project was completed (Tews 2007).

Any alternative that does not have long lasting impacts on stream stability should only have short-term impacts to the trout population. Based on the Brewery Flats example, these impacts could be very short-lived. Less than 10% of Big Spring Creek would be excavated during this project. High trout numbers, and fish displaced downstream, would likely repopulate the upper creek shortly after the project is completed. The risk assessment indicated that risks to trout were insignificant to very low (CDM, 2008).

Invertebrates. Under this alternative, invertebrates would be completely removed from the upper 3 subreaches of the creek. This impact would be similar to what is seen following rotenone treatments used to kill non-native fish from streams. In these studies, invertebrate communities, both taxa richness and abundances, essentially returned to pre-treatment conditions within 2 years (Whelan 2002), although some recolonization was evident as soon as several month after the treatments. This same length of time for invertebrate recolonization would be anticipated under this alternative, although recolonization may occur faster than alternative 4A because less area would be remediated.

Aquatic Plants. Under this alternative, all aquatic plants and seed banks stored in the sediment would be completely removed from the upper 3 subreaches of the creek. Upstream seed sources, albeit limited, would likely begin to re-establish aquatic plants within 2 years

DRAFT

following completion of the project. Waterfowl activity and movement, prominent in the creek, may assist in spreading new seeds to the remediated areas. Even so, it may take several years for aquatic vegetation to return to conditions seen prior to excavation actions, although recolonization may occur faster than alternative 4A because less area would be remediated.

Terrestrial Vegetation. Under this alternative, impacts to the woody plants on both streambanks along the entire length of the upper creek would be damaged or removed due to the need for excavator operators to have adequate range of motion for activities and unimpeded view of the stream. Depending on the extent of damage, vegetation would regain original size and vigor in 2-5 years. The degree of damage under this alternative would be less than 4A, because only the upper 1.25 miles would be impacted. Impacts would be less than the mechanical dredging alternatives, due to the ability of the excavators to conduct some work in the dry stream channel. Impacts would still be greater than with hydraulic dredging.

5.5.6 Implementability

This alternative is both technically and administratively feasible. Water diversion, waste removal, transportation and disposal, and stream restoration are readily implementable using conventional construction techniques. Stream restoration has been successfully completed on numerous streams and is a proven technology, if implemented correctly. Key project components, such as the availability of equipment, construction expertise, and sufficient landfill space, are present and would aid in the timely implementation and successful execution of the proposed project.

DRAFT

5.5.7 Cost

The total present-worth cost for this alternative has been estimated at $2,650,698 for Alternative 4A and $1,566,289 for Alternative 4B. The assumptions used in estimating these costs are presented in Table 24. Table 25 and Table 26 present the cost details associated with implementing Alternative 4A and 4B, respectively. The total cost includes the present-worth value of 30 years of annual maintenance and monitoring costs in addition to capital costs.

Conceptual Design and Assumptions

Dry excavation would be accomplished by using a diversion or series of diversions to reroute the flow in Big Spring Creek while contaminated sediment is excavated and removed from the streambed. The diversions could include pumping and piping, use of a siphon, excavation of a temporary diversion channel, or a combination of these technologies. Sheet piling and coffer dams are frequently used for construction dewatering projects; however, the coarse nature of the sediment (i.e., abundant cobbles in a high percentage of the streambed) is probably not conducive to driving sheet piling. Sometimes a stream is permanently relocated and then sediment is removed from the former stream by dry excavation. Given the ownership patterns and residential setting along this section of Big Spring Creek, it has been assumed that permanent stream relocation is not a viable option. For the purpose of the feasibility study, it is assumed that the stream would be diverted by pumps and piping in 1,500-foot long sections. Eight pumps would be used to pump the 150 cfs flow in Big Spring Creek into 24-inch HDPE pipe. An additional four pumps would be left in standby in case of a pump failure of any of the primary pumps.

Once the flow in Big Spring Creek is diverted, conventional excavation equipment such as hydraulic excavators and off-road haul trucks would be used to remove streambed sediment to a depth of 6 inches. Although this alternative is referred to as “dry excavation”, this term refers to excavation of sediment in the absence of flowing water and does not mean that the sediment would actually be dry. The streambed would most likely be saturated and could have pools of residual standing water or inflow from springs that render the sediment too wet for off-site transportation and disposal. Therefore, lined storage ponds would be required to temporarily store and dewater the sediment. The water would require settlement in ponds or treatment/filtration to remove suspended sediment which could contain PCBs. After treatment, the water would be discharged to Big Spring Creek or land applied.

Additional processing of sediment would include screening/sorting of the sediment to recover oversize material (>1/4 inch), segregating and collecting the fine sediment fraction, and dewatering of the sediment prior to transportation and disposal. The oversize material would be sorted and blended into gradations based on the geomorphic type (i.e., riffle, run, pool, etc.). Supplemental fines (i.e., 1/4-inch minus) would be blended in as necessary to achieve gradations similar to the pre-excavation condition. The blended oversize material would then be returned to the streambed based on geomorphic type and the streambed reconstructed to near the original condition. Streambanks would be left undisturbed to the extent practical; however, equipment access, haul roads, and haul truck traffic would likely necessitate some streambank reconstruction. Similarly, streambank vegetation would be left intact to the extent practical during removal and replacement of streambed material, but some removal and replacement is expected to occur. Vegetation would be replaced with like materials, but not necessarily the same size.

Temporary sediment storage and processing areas would be selected to minimize disturbance to vegetation and developed areas. Relatively flat open areas, such as meadows or pasture areas, would be suitable for sediment storage and processing areas. At the completion of the project, these areas would be graded to the approximate original contour, and seeded with a mixture of native grasses.

The general construction steps for implementing Alternative 4 are as follows:

- site preparation including road improvements and clearing and grubbing;
- preparation of temporary sediment storage and processing (dewatering, screening/sorting, water collection and treatment) areas;
- installation of stream diversions;
- excavation of streambed sediment;
- hauling sediment to temporary staging and processing areas;
- screening of sediment to remove oversize material (material larger than approximately 1/4-inch;
- dewatering of sediment so that free-draining liquids are removed;
- collection and treatment of water and suspended sediment from the dewatering operation;

DRAFT

- monitoring of PCB concentrations and turbidity levels in the treated water;
- discharge of treated water to Big Spring Creek;
- collection and loading of dewatered sediment into trucks and hauling to the landfill;
- sorting the oversize material into gradations based on geomorphic type that approximate the pre-construction condition, including the addition of 1/4-inch minus material;
- hauling the oversize material and placing it back in the streambed;
- restoring the streambed to near the pre-excavation condition;
- removal and reclamation of stream diversions, haul roads, and temporary sediment staging and storage areas; and
- re-establishing vegetation in disturbed areas.

Dry excavation offers the following advantages over other technologies:

- little to no chance of contaminant resuspension since the removal would be completed in the absence of flowing water;
- the sediment would have a lower water content than mechanical and hydraulic dredging;
- the lower water content would result in less sediment dewatering and water treatment than mechanical or hydraulic dredging;
- dry excavation offers the opportunity for more controlled and more thorough removal than mechanical and hydraulic dredging; and
- dry excavation would likely be less destructive to streambank vegetation than mechanical dredging since equipment can operate to a greater extent within the streambed and less on the streambanks.

Disadvantages of dry excavation include:

- risk of overtopping and localized flooding in the event that the diversion fails (i.e., a pump or piping failure, etc.).
- dry excavation removes all sediment regardless of size;
- requires screening/sorting of the sediment to capture and reuse oversize material;
- removal and replacement of material in the upper 6 inches would likely cause more habitat disturbance than hydraulic dredging; and
- requires extensive stream reconstruction/restoration.

DRAFT

5.6 Alternative 5: Complete Removal of PCB-Impacted Stream Sediment Via Mechanical Dredging with Disposal at a Solid Waste Landfill

The remediation strategy for Alternative 5 involves complete removal of PCB-impacted stream sediment via mechanical dredging. Mechanical dredging involves using heavy equipment, such as a hydraulic excavator or dragline, to excavate sediment from streambed. Mechanical dredging often employs the use of a barge to support excavating equipment. Given the relatively small size of Big Spring Creek and the shallow nature of the stream, a barge would not be practical and the dredging work would be completed from the stream banks or with equipment placed in the stream.

As described in Section 5.1, complete removal would involve sediment being mechanically dredged from the stream bed to a depth of 36 inches using conventional equipment such as a hydraulic excavator. The excavated material would be loaded onto haul trucks and transported to temporary staging and containment areas for dewatering and processing. The sediment would be screened to remove oversized material (>1/4-inch) that is not likely to be contaminated. The segregated oversized sediment would be returned to the creek. After screening and dewatering, the fine sediment would be transported via truck to a permitted Class II municipal solid waste landfill for disposal. Water collected in the dewatering process would be treated to remove turbidity and PCBs in suspended sediment and discharged into Big Spring Creek. Mechanical dredging would alter the streambed so extensive stream restoration construction would be required.

5.6.1 Overall Protection of Human Health and the Environment

As shown in the human health risk assessments (CDM, 2005, 2008, and 2009), the only significant risk to human health is the consumption of PCB-impacted fish. Risks to human health from exposure via direct contact or ingestion of stream sediment and direct contact or ingestion of stream water were not significant.

The implementation of this alternative would provide a means of reducing the risk to both human health and the environment. Compared to the partial removal alternatives, complete removal of PCB-impacted sediment would provide the greatest degree of risk reduction from exposure to PCBs for both aquatic organisms and terrestrial organisms that feed on aquatic organisms. The risk to human health from consumption of PCB-impacted fish would also be reduced as PCB concentrations are reduced in the food chain; however, complete removal of PCB-impacted sediment provides the greatest degree of habitat destruction, which could be detrimental to fish and other aquatic organisms until the stream and suitable habitat are restored. In addition, mechanical dredging has a high potential for resuspending and redepositing PCB-laden sediment on the streambed since the dredging is completed in the presence of water. This reduces the overall degree of protection provided by this alternative. A higher degree of protection can be provided by Alternative 7 (dry excavation).

5.6.2 Compliance With ARARs

A comprehensive list of federal and state ARARs is presented in Section 2.0 and Appendix E. ARARs are divided into contaminant-specific, location-specific, and action-specific requirements.

DRAFT

There are no state contaminant-specific ARARs for PCBs in stream sediment. Table 2 through Table 5 show that federal contaminant-specific ARARs for PCB remediation waste (Section 3.1.2.1) are not being met in stream sediment. Under the assumptions of the dredging conditions described above for Alternative 5, the post-remediation sediment PCB concentrations would meet the federal chemical-specific ARAR-based PRG of 1 mg/kg (1,000 µg/kg) for PCB remediation waste in high occupancy areas (see Section 3.1.2.1); however, it should be noted that the EPA regional administrator may also require cleanup to more stringent levels based on proximity to areas such as residences, wetlands, fisheries, etc. While not an ARAR, the TMDL target concentration for PCBs in Big Spring Creek of 189 µg/kg is “To Be Considered” (Section 2.0). This concentration is based on the probable effects level developed by EPA (1997). DEQ’s TMDL report calls for the average Aroclor 1254 concentration to be less than 189 µg/kg. The TMDL target concentration would likely be met in the stream sediment after dredging in all subreaches under Alternative 5, provided that resuspension and redeposition of PCBs during mechanical dredging can be controlled. Removal of the in-stream sediment would remove the source of PCBs and should result in improvements in PCB concentrations in fish and other aquatic organisms.

The TMDL target concentration for PCBs in fish tissue (<0.025 mg/kg) would likely be met in this alternative provided the mechanical dredging is thorough and there are no detectable PCBs in sediment following remediation.

Six surface water samples were collected from Reaches 2, 3, and 4 of Big Spring Creek during the risk assessment (CDM, 2005), and PCBs were not detected in these samples. The detection limit for PCBs was less than the EPA drinking water drinking water maximum contaminant level (MCL) of 0.5 µg/L and the DEQ surface water criterion of 0.014 µg/L for protection of aquatic life. Therefore, contaminant-specific ARARS for PCBs are currently being met in surface water in Big Spring Creek. Contaminant-specific ARARs for surface water would need to be met during mechanical dredging and would require monitoring.

Implementation of this alternative is expected to satisfy air quality regulations because disposal of PCB-impacted sediment in a solid waste landfill would stabilize contaminant sources and inhibit fugitive emissions.

Location-specific ARARs are expected to be met in the implementation of this alternative. Contacts with the appropriate agencies and acquisition of required permits related to streambeds, floodplains, and archaeological/paleontological resources would be completed.

Action-specific ARARs are expected to be met including the disposal requirements of TSCA and the hydrological regulations contained in the Strip and Underground Mine Reclamation Act. Mechanical dredging would require coordination with the Montana Department of Fish, Wildlife, and Parks, The U.S. Army Corps of Engineers, the Montana Department of Natural Resources and Conservation, and the Montana Department of Environmental Quality. Revegetation requirements contained in the Surface Mining and Control Reclamation Act would be met. State of Montana air quality regulations related to dust suppression and control during construction activities would be met using water sprays where applicable, i.e. the excavation area and haul roads with heavy vehicular traffic.

Occupational Safety and Health Administration (OSHA) requirements would be met by requiring appropriate safety training for all on-site workers during the construction phase. Site activities would be conducted under the guidance of a Health and Safety Plan for the site as per OSHA 29 CFR 1910.120. Site personnel would have completed 40-hour hazardous waste operations

DRAFT

and emergency response training and would be current on the 8-hour annual refresher training as required by OSHA.

5.6.3 Long-Term Effectiveness and Permanence

This alternative would reduce contaminant mobility at the site by removing the highest risk, solid media contaminant sources and disposing of these wastes in a permitted Class II landfill. PCB-impacted sediment would be encapsulated in a permitted Class II landfill, which would effectively isolate this waste and reduce contaminant mobility. This alternative achieves long-term risk reduction by transporting the contaminated materials to a facility that specializes in the storage and disposal of non-hazardous wastes, thus providing for the long-term permanence of the remedy since point sources of PCBs have been removed from both the upper and lower hatchery. Reliable monitoring results to show reductions in PCBs in fish tissue would take several years to obtain. Rainbow and brown trout in the creek are currently impacted with PCBs. Therefore, it would take an estimated 6 to 8 years for new generations of fish that have not previously been impacted by PCBs to grow to the appropriate size for sampling and accurately reflect the post-remediation PCB concentrations in fish tissue. FWP protocols for monitoring fish in Big Spring Creek include the collection of rainbow trout (13-15 inches total length) and brown trout (14-16 inches total length).

Of the three removal methods, mechanical dredging is expected to provide for the least controlled and least thorough removal because it is completed in the presence of water. Although barriers would be used to isolate portions of the stream during mechanical dredging, the presence of murky water would provide for little or no visibility of the streambed and there is high probability that PCBs could be resuspended and redeposited on the stream. Because of the complete removal to 36 inches, Alternative 5 would provide for the long-term effectiveness and permanence of this alternative if the resuspension and redeposition of PCB-laden sediment can be controlled. In addition to redeposition of PCBs in the streambed, the sediment would be saturated (plus excess water trapped in the excavator bucket) and is likely to leak from haul trucks and deposit PCBs on the streambank area and on haul roads.

Removal of the stream sediment to a depth of 36 inches by mechanical dredging would effectively destroy the aquatic habitat for an estimated 2 to 5 years until stream restoration is completed and sufficient food sources to support a healthy population of aquatic insects is re-established. Fish are expected return to the area after habitat and food sources are restored.

Stream restoration projects have been successfully completed on numerous streams. A period of 2 to 5 years is typically required after construction to re-establish vegetation. Stream restoration is a proven technology if implemented properly, which supports to the long-term effectiveness and permanence of Alternative 5.

5.6.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

Reduction of contaminant mobility is the primary objective of this alternative. The volume and toxicity of the contaminants in the waste materials would not be physically or chemically reduced. The removal of the impacted sediment from the streambed would reduce the contaminant mobility by moving the waste to a secure location. Since the removal would be completed in the presence of water, there is high probability of resuspending and redepositing PCB-laden sediment in the streambed, which reduces the effectiveness of this alternative for

DRAFT

controlling contaminant mobility. The dewatered sediment would be encapsulated in permitted Class II landfill, whose physical location is protected from erosion and water infiltration.

5.6.5 Short-Term Effectiveness

It is anticipated that construction activities related to the implementation of this alternative would be completed in one construction season. Impacts associated with construction activities should not significantly impact human health.

Short term air quality impacts to the immediate environment may occur due to the relatively large volume of sediment removal. The wet nature of the sediment should control fugitive dust; however, dry sediment being stored prior to hauling to the landfill may require the use of water spray to control fugitive dust. The use of heavy equipment and haul trucks, and the need for haul roads, staging areas, and sediment processing areas would impact local residents in the project area during construction activities. Other short-term impacts to local residents would include potential noise and dust from construction activities. Noise can be controlled through the use of set working hours. Control of fugitive dust may require the use of water sprays.

On-site workers would be protected by following a site specific Health and Safety Plan, employing appropriate personal protective equipment and by following proper operating and safety procedures. However, short term air quality impacts to the immediate environment may occur due to the relatively large volume of waste handling, dewatering, and hauling. Control of fugitive dust may require the use of water sprays.

Impacts to the surrounding community are expected to be minimal due to the location of the project site. The most significant short-term impact to the surrounding community would involve increased vehicle traffic, particularly haul truck traffic, with associated safety hazards and potential dust generation. A traffic control plan, including warning signs and possibly flaggers, would be required while transporting these wastes.

DRAFT

Direct Effects on Biota. Under Alternative 5, complete removal (upper 36-inches) via mechanical dredging would be conducted in all subreaches of the upper Creek. Mechanical dredging is considered to be the most invasive and destructive alternative affecting aquatic life in the stream. More specifically, Alternative 5 would be considered the most invasive alternative proposed. Removing the upper 36-inches via mechanical dredging from all subreaches would likely remove all periphyton, rooted aquatic plants, and invertebrates from the creek. As remediation moves downstream, most fish would eventually be driven out of the entire upper section of the creek to areas below the confluence with the East Fork, leaving the upper section largely fishless until the channel is completed re-graded and constructed with fresh material until invertebrates recolonize the area. Fish driven downstream would compete for habitat and food with fish inhabiting the lower sections and could result in reduced growth and even mortality depending on the resource availability and partitioning.

Direct adult and juvenile trout mortality should be low for these mobile organisms. Fish eggs and sac fry found in the gravel during dredging would likely have close to 100% mortality. Dredging time restrictions could minimize this loss. It would take an estimated 21 months to dredge the entire 2.77 miles, so it is reasonable to expect the entire area would be dredged during the critical spawning and rearing periods. Surveys conducted on Big Spring Creek indicate brown trout spawn between mid-October and late November. Brown trout eggs hatch during the winter and the sac fry probably stay in the gravels until March. Spawning for rainbow trout likely runs from March through May, with swim-up (emergence from the gravels) occurring somewhere between early June and late July. If dredging is postponed until after trout swim-up in June or July, mortality of YOY rainbow trout should be reduced. Length of dredging time and seasonality of dredging may make such time restrictions impractical or require dredging over three seasons. Survival of eggs and fry would not likely occur in riffle crests left in place because the water in these areas would be extremely turbid during adjacent dredging activities. It is unlikely that reproduction from brown trout in the upper 2.77 miles of Big Spring Creek provides much recruitment to Big Spring Creek; dredging impacts to brown trout reproduction in this reach would likely have little impact on brown trout numbers in Big Spring Creek. However, rainbow trout spawning in the two miles below the lower hatchery may contribute substantially to the rainbow trout population in Big Spring Creek.

Recolonization. The length of time anticipated for recolonization of fish, invertebrates, rooted aquatic plants, and periphyton to the upper creek under Alternative 5 would likely be the longest of all proposed alternatives. Unfortunately, the most impacted areas of the creek are near the sources of the creek, that would serve as an upstream source of plants and animals to assist in the recolonization of the dredged portion of the creek.

Fish. Under this alternative, fish would be driven out of the upper section of the creek due to dredging activities. The length of time required to mechanically dredge under this alternative would likely overlap the spawning periods of both spring spawning rainbow trout and fall spawning brown trout. Impacts to spawning fish likely extend beyond actual physical removal and destruction during dredging by reducing sediment stability until after a high flow period (Harvey and Lisle 1998). Even when the creek is rebuilt, it may take several years for the periphyton, aquatic vegetation, and invertebrates to return to the remediated sections of the creek that would allow fish to recolonize the area in any significant numbers.

Invertebrates. Under this alternative, invertebrates would be completely removed from the upper creek. This impact would be similar to what is seen following rotenone treatments used to kill fish from streams. In these studies, invertebrate communities, both taxa richness and abundances, essentially returned to pre-treatment conditions within 2 years (Whelan 2002), although recolonization was evident as soon as several months after the treatments. This same length of time for invertebrate recolonization would be anticipated under this alternative.

Aquatic Plants. Under this alternative, all aquatic plants and seed banks stored in the sediment would be completely removed from the upper creek. Upstream seed sources, albeit limited, would likely begin to re-establish aquatic plants within 2 years following completion of the project. Waterfowl activity and movement, prominent in the creek, may assist in spreading new seeds to the remediated areas. Even so, it may take several years for aquatic vegetation to return to conditions seen prior to dredging actions.

Terrestrial Vegetation. Under this alternative, much of the woody plants on both streambanks along the entire length of the upper creek would be damaged or removed due to the need for excavator operators to have adequate range of motion for activities and unimpeded view of the stream. Depending on the extent of damage, vegetation would regain original size and vigor in 2-5 years.

DRAFT

5.6.6 Implementability

This alternative is technically implementable. Sediment removal, transportation and disposal, and stream restoration are readily implementable using commercially available equipment and materials. Key project components, such as the availability of equipment, construction expertise, and sufficient landfill space, are present and would aid in the timely implementation and successful execution of the proposed project.

The administrative feasibility of this alternative is questionable. The degree of habitat destruction, the high potential for resuspension and mobilization of PCBs, and the degree of streambank vegetation that would need to be removed make this alternative unattractive for FWP to be able to issue a Stream Protection Act 124 permit.

5.6.7 Cost

The total present-worth cost for this alternative has been estimated at $12,192,561. The assumptions for used in estimating these costs are presented in Table 18. Table 27 presents the cost details associated with implementing this alternative. The total cost includes the present-worth value of 30 years of annual maintenance and monitoring costs in addition to capital costs.

<u>Conceptual Design and Assumptions</u>

Mechanical dredging would be completed using conventional excavation equipment such as hydraulic excavators and off-road haul trucks to remove streambed sediment to a depth of 3 feet. The sediment would be saturated and additional water would be entrained in the bucket as the sediment is excavated. Therefore, lined storage ponds would be required to temporarily store and dewater the sediment. The water would require settlement in ponds or treatment/filtration to remove suspended sediment which could contain PCBs. After treatment, the water would be discharged to Big Spring Creek or land applied.

Additional processing of sediment would include screening/sorting of the sediment to recover oversize material (>1/4 inch), segregating and collecting the fine sediment fraction, and dewatering of the sediment prior to transportation and disposal. The oversize material would be sorted and blended into gradations based on the geomorphic type (i.e., riffle, run, pool, etc.). Supplemental fines (i.e., 1/4-inch minus) would be blended in as necessary to achieve gradations similar to the pre-excavation condition. The blended oversize material would then be returned to the streambed based on geomorphic type and the streambed reconstructed to near the original condition. Streambanks would be left undisturbed to the extent practical; however, equipment access, haul roads, and haul truck traffic would likely necessitate some streambank reconstruction.

To implement this alternative, vegetation would need to be removed from the majority of the streambank, at least on one side of the stream, to allow access and effective loading of haul trucks. Vegetation removal could potentially be lessened through the use of conveyor systems that could span over the vegetation. Damaged vegetation would be replaced with like materials, but not necessarily the same size.

The water and suspended sediment collected from the sediment dewatering could be pumped to a settling tank for the first stage of water treatment. A flocculant, such as Chitosan, can be

DRAFT

added to increase the settling velocity of fine particles and reduce the required holding time in the settling tank. A preliminary bench-scale test of Chitosan on fine sediment collected from Big Spring Creek indicated that suspended sediment rapidly settled with the addition of a Chitosan solution, while suspended sediment in a control sample without Chitosan did not rapidly settle.

After the initial treatment in a settling tank, the water can be treated through sand filters and, if necessary, a series of bag filters (i.e., 25, 5, and 1 micron filters) to “polish” the water prior to discharge into Big Spring creek. Both turbidity and PCBs would be monitored to verify compliance with the terms of the 318 permit issued by DEQ.

After dewatering is completed, the sediment would be loaded into a haul truck for transportation to the landfill. The sediment would likely be disposed of at the Montana Waste Systems High Plains Landfill located in Great Falls, Montana.

Temporary sediment storage and processing areas would be selected to minimize disturbance to vegetation and developed areas. Relatively flat open areas, such as meadows or pasture areas, would be suitable for sediment storage and processing areas. At the completion of the project, these areas would be graded to the approximate original contour, and seeded with a mixture of native grasses.

The general construction steps for implementing Alternative 5 are as follows:

- site preparation including road improvements and clearing and grubbing;
- preparation of temporary sediment storage and processing (dewatering, screening/sorting, water collection and treatment) areas;
- installation of sediment control barriers;
- mechanical dredging of streambed sediment;
- hauling sediment to temporary staging and processing areas;
- screening of sediment to remove oversize material (material larger than approximately 1/4-inch;
- dewatering of sediment so that free-draining liquids are removed;
- collection and treatment of water and suspended sediment from the dewatering operation;
- monitoring of PCB concentrations and turbidity levels in the treated water;
- discharge of treated water to Big Spring Creek;
- collection and loading of dewatered sediment into trucks and hauling to the landfill;
- sorting the oversize material into gradations based on geomorphic type that approximate the pre-construction condition, including the addition of 1/4-inch minus material;
- hauling the oversize material and placing it back in the streambed;

DRAFT

- restoring the streambed to near the pre-excavation condition;
- removal and reclamation of haul roads, and temporary sediment staging and storage areas; and
- re-establishing vegetation in disturbed areas.

Mechanical dredging offers the following advantages over other technologies:

- removes sediment at nearly the in-situ water content (lower than hydraulic dredging);
- requires less sediment dewatering than hydraulic dredging; and
- achieves deeper removal than hydraulic dredging.

Disadvantages of mechanical dredging include:

- requires extensive haul roads along creek;
- destructive to stream bank and vegetation from equipment and haul trucks;
- removes all sediment regardless of size;
- requires large staging area(s) for screening/sorting and dewatering;
- requires screening/sorting of the sediment to capture and reuse oversize material;
- high probability for resuspension and redeposition of PCB-laden sediment on the streambed;
- deeper sediment removal (3 feet) could potentially introduce streambed and/or streambank instability; and
- requires extensive stream reconstruction/restoration.

DRAFT

5.7 Alternative 6: Complete Removal of PCB-Impacted Stream Sediment Via Hydraulic Dredging with Disposal at a Solid Waste Landfill

The remediation strategy for Alternative 6 involves complete removal of PCB-impacted stream sediment via hydraulic dredging. As described in Section 5.1, complete removal is defined as removal of sediment to a depth of 36 inches. The suction dredge pilot test that was completed in the fall of 2006 showed that a small suction dredge could be used to remove fine sediment to a depth of about 5 to 7 inches. Therefore, a larger, self-propelled dredge with an articulating arm and cutterhead would be used to achieve sediment removal to a depth of 36 inches. Cutterheads come in a variety of designs, but are typically comprised of some type of rotating blades or augers used to dislodge sediment so that it can be retrieved via suction. In a stream with abundant cobbles, such as Big Spring Creek, the cutterhead does not necessarily mobilize the large particles, but rather pushes them out of the way so that the underlying fine particles can be retrieved in slurry form via suction. The sediment slurry would be dewatered and the water would be treated and either discharged back into the creek or land applied. The dewatered sediment would be transported via truck to a permitted Class II municipal solid waste landfill for disposal.

Dewatering of sediment and treatment of the slurry water could be accomplished by a variety of methods including settling ponds, geotextile tubes, or commercially available treatment systems. The following describes a commercially available system that has been used to treat dredge slurry from other PCB cleanup projects. Dredge slurry could be pumped into a series of filter boxes to dewater the sediment. A filter box is a 25 cubic yard metal box that is lined with a geotextile filter fabric. The geotextile filter fabric retains the sediment, while allowing the water to drain. The sediment retained on the filter fabric is then recovered from the filter box and segregated for disposal. Sediment that is allowed to drain in a filter box should pass the "paint filter test", which is the standard used to determine if free-draining liquids are present. Solid waste landfills cannot accept wastes with free-draining liquids.

Water and suspended sediment that pass through the filter fabric would be collected in the base of the filter box and treated prior to being discharged back into Big Spring Creek. The water could be treated in a number of ways. A common method is the use of a multi-stage process of settling and filtration. Chitosan, a flocculant derived from crustacean shells (crab, shrimp, and lobster), can be added to the water and suspended sediment mixture to decrease the settling time for colloidal particles if necessary. After passing through a settling tank, the water could then pass through sand filters and be "polished" through a series of bag filters (i.e., 25 micron, 5 micron, and 1 micron) as necessary to achieve water quality standards for PCBs and turbidity prior to discharging the water back into Big Spring Creek.

5.7.1 Overall Protection of Human Health and the Environment

As shown in the human health risk assessments (CDM, 2005, 2008, and 2009), the only significant risk to human health is the consumption of PCB-impacted fish. Risks to human health from exposure via direct contact or ingestion of stream sediment and direct contact or ingestion of stream water were not significant.

The implementation of this alternative would provide a means of reducing the risk to both human health and the environment. Compared to the partial removal alternatives, complete removal of PCB-impacted sediment would provide the greatest degree of risk reduction from exposure to PCBs for both aquatic organisms and terrestrial organisms that feed on aquatic organisms. The risk to human health from consumption of PCB-impacted fish would also be reduced as PCB concentrations are reduced in the food chain; however, complete removal of PCB-impacted sediment provides the greatest degree of habitat destruction, which could be detrimental to fish and other aquatic organisms until the stream and suitable habitat are restored.

5.7.2 Compliance With ARARs

A comprehensive list of federal and state ARARs is presented in Section 2.0 and Appendix E. ARARs are divided into contaminant-specific, location-specific, and action-specific requirements.

There are no state contaminant-specific ARARs for PCBs in stream sediment. Table 2 through Table 5 show that federal contaminant-specific ARARs for PCB remediation waste (Section

DRAFT

3.1.2.1) are not being met in stream sediment. Under the assumptions of the dredging conditions described above for Alternative 6, the post-remediation sediment PCB concentrations would meet the federal chemical-specific ARAR-based PRG of 1 mg/kg (1,000 µg/kg) for PCB remediation waste in high occupancy areas (see Section 3.1.2.1); however, it should be noted that the EPA regional administrator may also require cleanup to more stringent levels based on proximity to areas such as residences, wetlands, fisheries, etc. While not an ARAR, the TMDL target concentration for PCBs in Big Spring Creek of 189 µg/kg is “To Be Considered” (Section 2.0). This concentration is based on the probable effects level developed by EPA (1997). DEQ’s TMDL report calls for the average Aroclor 1254 concentration to be less than 189 µg/kg. The TMDL target concentration would likely be met in the stream sediment after dredging in all subreaches under Alternative 6, provided that resuspension and redeposition of PCBs during mechanical dredging can be controlled. Removal of the in-stream sediment would remove the source of PCBs and should result in improvements in PCB concentrations in fish and other aquatic organisms.

The TMDL target concentration for PCBs in fish tissue (<0.025 mg/kg) would likely be met in this alternative provided the hydraulic dredging is thorough and there are no detectable PCBs in sediment following remediation.

Implementation of this alternative is expected to satisfy air quality regulations because disposal of PCB-impacted sediment in a solid waste landfill would stabilize contaminant sources and inhibit fugitive emissions. Contaminant-specific ARARs for surface water would need to be met during hydraulic dredging and would require monitoring.

Location-specific ARARs are expected to be met in the implementation of this alternative. Contacts with the appropriate agencies and acquisition of required permits related to streambeds, floodplains, and archaeological/paleontological resources would be completed.

Action-specific ARARs are expected to be met including the disposal requirements of TSCA and the hydrological regulations contained in the Strip and Underground Mine Reclamation Act. Hydraulic dredging would require coordination with the Montana Department of Fish, Wildlife, and Parks, The U.S. Army Corps of Engineers, the Montana Department of Natural Resources and Conservation, and the Montana Department of Environmental Quality. Revegetation requirements contained in the Surface Mining and Control Reclamation Act would be met. State of Montana air quality regulations related to dust suppression and control during construction activities would be met using water sprays where applicable, i.e. the excavation area and haul roads with heavy vehicular traffic.

Occupational Safety and Health Administration (OSHA) requirements would be met by requiring appropriate safety training for all on-site workers during the construction phase. Site activities would be conducted under the guidance of a Health and Safety Plan for the site as per OSHA 29 CFR 1910.120. Site personnel would have completed 40-hour hazardous waste operations and emergency response training and would be current on the 8-hour annual refresher training as required by OSHA.

5.7.3 Long-Term Effectiveness and Permanence

This alternative would reduce contaminant mobility at the site by removing the highest risk, solid media contaminant sources and disposing of these wastes in a permitted Class II landfill. PCB-impacted sediment would be encapsulated in a permitted Class II landfill, which would

DRAFT

effectively isolate this waste and reduce contaminant mobility. This alternative achieves long-term risk reduction by transporting the contaminated materials to a facility that specializes in the storage and disposal of non-hazardous wastes, thus providing for the long-term permanence of the remedy since point sources of PCBs have been removed from both the upper and lower hatchery. Reliable monitoring results to show reductions in PCBs in fish tissue would take several years to obtain. Rainbow and brown trout in the creek are currently impacted with PCBs. Therefore, it would take an estimated 6 to 8 years for new generations of fish that have not previously been impacted by PCBs to grow to the appropriate size for sampling and accurately reflect the post-remediation PCB concentrations in fish tissue. FWP protocols for monitoring fish in Big Spring Creek include the collection of rainbow trout (13-15 inches total length) and brown trout (14-16 inches total length).

Hydraulic dredging is expected to remove a high percentage of PCBs from the streambed and is estimated to have a medium probability for resuspension and redeposition of PCB-laden sediment on the streambed. Therefore, it is expected to provide for the controlled and reasonably thorough removal because the suction action should recover a high percentage of the dislodged sediment particles. Because of the complete removal to 36 inches, Alternative 6 would provide for the long-term effectiveness and permanence of this alternative if the resuspension and redeposition of PCB-laden sediment can be controlled.

Removal of the stream sediment to a depth of 36 inches by hydraulic dredging would effectively destroy the aquatic habitat for an estimated 2 to 5 years until stream restoration is completed and sufficient food sources to support a healthy population of aquatic insects is re-established. Fish are expected return to the area after habitat and food sources are restored.

Stream restoration projects have been successfully completed on numerous streams. A period of 2 to 5 years is typically required after construction to re-establish vegetation. Stream restoration is a proven technology if implemented properly, which supports to the long-term effectiveness and permanence of Alternative 6.

DRAFT

5.7.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

Reduction of contaminant mobility is the primary objective of this alternative. The volume and toxicity of the contaminants in the waste materials would not be physically or chemically reduced. The removal of the impacted sediment from the streambed would reduce the contaminant mobility by moving the waste to a secure location. Since the removal would be completed in the presence of water, there is possibility of resuspending and redepositing PCB-laden sediment in the streambed, which reduces the effectiveness of this alternative for controlling contaminant mobility. The suction action should recover a high percentage of the dislodged sediment particles, which would help control contaminant mobility. The dewatered sediment would be encapsulated in permitted Class II landfill, whose physical location is protected from erosion and water infiltration.

5.7.5 Short-Term Effectiveness

It is anticipated that construction activities related to the implementation of this alternative would be completed in one construction season. Impacts associated with construction activities should not significantly impact human health.

Short term air quality impacts to the immediate environment may occur due to the relatively large volume of sediment removal. The wet nature of the sediment should control fugitive dust; however, dewatered sediment being stored prior to hauling to the landfill may require the use of water spray to control fugitive dust. The use of heavy equipment and haul trucks, and the need for haul roads, staging areas, and sediment processing areas would impact local residents in the project area during construction activities. Other short-term impacts to local residents would include potential noise and dust from construction activities. Noise can be controlled through the use of set working hours. Control of fugitive dust may require the use of water sprays.

On-site workers would be protected by following a site specific Health and Safety Plan, employing appropriate personal protective equipment and by following proper operating and safety procedures. However, short term air quality impacts to the immediate environment may occur due to the relatively large volume of waste handling, dewatering, and hauling. Control of fugitive dust may require the use of water sprays.

Impacts to the surrounding community are expected to be minimal due to the location of the project site. The most significant short-term impact to the surrounding community would involve increased vehicle traffic, particularly haul truck traffic, with associated safety hazards and potential dust generation. A traffic control plan, including warning signs and possibly flaggers, would be required while transporting these wastes.

Direct Effects on Biota. Under Alternative 6, complete removal (upper 36-inches) via hydraulic dredging would be conducted in all subreaches of the upper creek. Hydraulic dredging is considered to be the least invasive and destructive alternative affecting aquatic life in the stream, although hydraulic dredging to the 36-inch depth would be far more invasive than Alternative 3, that involves dredging to a depth of only 6 inches. Removing the upper 36-inches via hydraulic dredging from all subreaches would likely remove all periphyton, rooted aquatic plants, and invertebrates from the creek. As remediation moves downstream, fish may be driven out of the upper creek, or they move upstream past the dredging activities. Fish driven out of the remediated areas would compete for habitat and food with fish inhabiting the other sections of the creek and could result in reduced growth and even mortality depending on the resource availability and partitioning.

Direct adult and juvenile trout mortality should be low for these mobile organisms. Fish eggs and sac fry found in the gravel during dredging would likely have close to 100% mortality. Dredging time restrictions could minimize this loss. It would take an estimated 3 months to dredge the entire 2.77 miles, so there is potential that only a portion of the project area would be dredged during the critical spawning and rearing period. Surveys conducted on Big Spring Creek indicate brown trout spawn between mid-October and late November. Brown trout eggs hatch during the winter and the sac fry probably stay in the gravels until March. Spawning for rainbow trout likely runs from March through May, with swim-up (emergence from the gravels) occurring somewhere between early June and late July. If dredging is postponed until after trout swim-up in June or July, mortality of YOY rainbow trout should be reduced. Survival of eggs and fry could occur in the streambed cobbles of riffle crests that are not dredged to preserve stream stability. It is unlikely that reproduction from brown trout in the upper 2.77 miles of Big Spring Creek provides much recruitment to Big Spring Creek; dredging impacts to brown trout reproduction in this reach would likely have little impact on brown trout numbers in Big Spring Creek. However, rainbow trout spawning in the two miles below the lower hatchery may contribute substantially to the rainbow trout population in Big Spring Creek.

DRAFT

Recolonization. The length of time anticipated for recolonization of fish, invertebrates, rooted aquatic plants, and periphyton to the upper creek under Alternative 6 would likely be less than complete removal via mechanical dredging or dry excavation alternatives because only the fines would be removed, leaving other habitat features in place. Unfortunately, the most contaminated areas of the creek are near the source of the creek, leaving only two small tributaries (Hansen and Castle Creek) that would serve as an upstream source of plants and animals to assist in the recolonization of the dredged portion of the creek.

Fish. Under this alternative, fish may be driven out of the upper section of the creek due dredging activities. The length of time required to hydraulic dredge under this alternative might overlap the spawning period of either spring spawning rainbow trout and fall spawning brown trout. Impacts to spawning fish likely extend beyond actual physical removal and destruction during dredging by reducing sediment stability until after a high flow period (Harvey and Lisle 1998). It may take several years for fines to re-deposit in the creek. Periphyton, aquatic vegetation, and invertebrates should return to the remediated sections of the creek faster than other alternatives, allowing fish to more rapidly recolonize the remediated area of the creek.

Invertebrates. Under this alternative, invertebrates would be completely removed from the upper creek. This impact would be similar to what is seen following rotenone treatments used to kill non-native fish from streams. In these studies, invertebrate communities, both taxa richness and abundances, essentially returned to pre-treatment conditions within 2 years (Whelan 2002), although recolonization was evident as soon as several months after the treatments. This same length of time for invertebrate recolonization would be anticipated under this alternative, although some recolonization may occur faster than Alternatives 5 and 7 because less habitat features would need to be restored within the remediated area.

Aquatic Plants. Under this alternative, all aquatic plants and seed banks stored in the sediment would be completely removed from the upper creek. Upstream seed sources, albeit limited, would likely begin to re-establish aquatic plants within 2 years following completion of the project. Waterfowl activity and movement, prominent in the creek, may assist in spreading new seeds to the remediated areas. Even so, it may take several years for aquatic vegetation to return to conditions seen prior to dredging actions, although recolonization may occur faster than Alternatives 5 and 7 because less habitat features would need to be restored within the remediated area.

Terrestrial Vegetation. Under this alternative, impacts to the woody plants on both streambanks along the entire length of the upper creek would be minimal, due to the fact that most activity would occur in-channel. Two situations would result in some damage: 1) where excavators are needed to lift and remove portable sediment control barriers; and 2) at the eight staging locations where access to and from the stream could cause damage to woody vegetation. Depending on the extent of damage, vegetation would regain original size and vigor in 2-5 years. The degree of damage under this alternative would be less than the mechanical dredging and dry excavation alternatives, but likely more than Alternative 3 because material would be removed to a greater depth.

5.7.6 Implementability

This alternative is technically implementable. Sediment removal, transportation and disposal, and stream restoration are readily implementable using commercially available equipment and materials. Key project components, such as the availability of equipment, construction

DRAFT

expertise, and sufficient landfill space, are present and would aid in the timely implementation and successful execution of the proposed project.

The administrative feasibility of this alternative is questionable. The degree of habitat destruction and the potential for resuspension and mobilization of PCBs would make this alternative potentially unattractive for FWP to be able to issue a Stream Protection Act 124 permit.

5.7.7 Cost

The total present-worth cost for this alternative has been estimated at $5,353,594. The assumptions used in estimating these costs are presented in Table 21. Table 28 presents the cost details associated with implementing this alternative. The total cost includes the present-worth value of 30 years of annual maintenance and monitoring costs in addition to capital costs.

<u>Conceptual Design and Assumptions</u>

A 4- or 6-inch portable dredge would not be powerful enough to achieve the target removal depth of 36 inches. Therefore, a larger, self-propelled dredge with an articulating arm and cutterhead would be used to achieve sediment removal to a depth of 36 inches. The cutterhead would move larger particles (i.e., cobbles and coarse gravel) so that the underlying finer particles can be mobilized by the suction action of the dredge. The target particle size would be 1/4-inch minus material. Although paint chips larger than 1/4 inch diameter have been observed in Big Spring Creek, it is assumed that the action of the dredge and the brittle nature of the paint chips would break the paint chips into smaller particles that can be recovered by the dredge. This phenomenon was observed in sediment samples that were shaken in sieves during the RI.

For the conceptual design and associated cost estimate, it is assumed that the dredge slurry is pumped into a series of 25-cubic yard filter boxes to dewater the sediment. The filter boxes are lined with a geotextile filter fabric to allow water drain from the sediment. The water and suspended sediment would be collected from the bottom of the filter box and pumped to a settling tank for the first stage of water treatment. A flocculant, such as Chitosan, can be added to increase the settling velocity of fine particles and reduce the required holding time in the settling tank. A preliminary bench-scale test of Chitosan on fine sediment collected from Big Spring Creek indicated that suspended sediment rapidly settled with the addition of a Chitosan solution, while suspended sediment in a control sample without Chitosan did not rapidly settle.

After the initial treatment in a settling tank, the water can be treated through sand filters and, if necessary, a series of bag filters (i.e., 25, 5, and 1 micron filters) to “polish” the water prior to discharge into Big Spring creek. Both turbidity and PCBs would be monitored to verify compliance with the terms of the 318 permit issued by DEQ.

Sediment would remain in filter boxes until the free-draining liquids have been removed. After draining is completed, the sediment would be removed from the filter boxes and loaded into a haul truck for transportation to the landfill. The sediment would likely be disposed of at the Montana Waste Systems High Plains Landfill located in Great Falls, Montana.

Since sediment would be remove to a depth of 36 inches and essentially all fine grained material would be removed, it has been assumed the fine-grained sediment would need to be replaced to maintain the stability and function of the stream. Replacement and blending of fine-grained material would be difficult in the presence of flowing water and since the coarse-grained sediment would remain in the stream. The removal depth of 36 inches would effectively destroy the existing streambed. Therefore, the streambed would require extensive restoration construction to provide proper habitat to maintain a healthy ecosystem.

Since the filter boxes, settling tanks, and filtration system components are relatively portable, it is assumed that the impact to property where dewatering and water treatment occurs would be relatively minor and would consist of small disturbances to grassy areas and the presence of tire tracks. These areas would be graded and reseeded as necessary to return the properties to pre-construction conditions.

The general construction steps for implementing Alternative 6 are as follows:

- mobilization and setting up the dredging, dewatering, and water treatment equipment;
- removal of 1/4-inch minus sediment with a dredge;
- pumping dredge slurry to a collection area such as filter boxes;
- dewatering of sediment so that free-draining liquids removed;
- collection and treatment of water and suspended sediment from the dewatering operation;
- monitoring of PCB concentrations and turbidity levels in the treated water;
- discharge of treated water to Big Spring Creek;
- collection and loading of dewatered sediment into trucks and hauling to the landfill;
- replacing and blending fine-grained sediment into the streambed;
- restoring the streambed to near the pre-excavation condition;
- removal and reclamation of haul roads, and temporary sediment staging, storage, and treatment areas; and
- re-establishing vegetation in disturbed areas.

Hydraulic dredging with a cutterhead offers the following advantages over other technologies:

- allows for the segregation and removal of fine particles only (1/4-inch minus);
- no screening or sorting of the sediment is required; and
- leaves gravel and cobbles in stream.

Disadvantages of hydraulic dredging with a cutterhead include:

- dredge slurry has a high water content and low solids content;

DRAFT

- extensive dewatering of sediment is required compared to mechanical dredging and dry excavation;

- the large dewatering volume requires treatment and handling of a large volume of water;

- resuspension of contaminants is likely with the cutterhead;

- although coarse-grained sediment (i.e., cobbles and coarse gravel) are left in the stream, they would be displace by the dredging action which would destroy the existing stream habitat features;

- deeper sediment removal (36 inches) and removal of fines could potentially introduce streambed and/or streambank instability; and

- addition and blending of fines into the coarse-grained sediment in the underwater environment is problematic;

- requires extensive stream reconstruction/restoration.

5.8 Alternative 7: Complete Removal of PCB-Impacted Stream Sediment Via Dry Excavation with Disposal at a Solid Waste Landfill

The remediation strategy for Alternative 7 involves complete removal of PCB-impacted stream sediment via dry excavation. Dry excavation involves temporarily rerouting the stream from its existing channel to allow the excavation and removal of contaminated sediment in the absence of flowing water. A diversion or series of diversions would be used to reroute the flow in Big Spring Creek while contaminated sediment is excavated and removed from the streambed. The diversions could include pumping and piping, use of a siphon, excavation of a temporary diversion channel, or a combination of these technologies.

As described in Section 5.1, complete removal would involve sediment being excavated from the stream bed to a depth of 36 inches using conventional equipment such as a hydraulic excavator. The excavated material would be loaded onto haul trucks and transported to temporary staging and containment areas for dewatering and processing. The sediment would be screened to remove oversized material (>1/4-inch) that is not likely to be contaminated. The segregated oversized sediment would be returned to the creek. After screening and dewatering, the fine sediment would be transported via truck to a permitted Class II municipal solid waste landfill for disposal. Water collected in the dewatering process would be treated to remove turbidity and PCBs in suspended sediment and discharged into Big Spring Creek. Dry excavation would alter the streambed so extensive stream restoration construction would be required.

5.8.1 Overall Protection of Human Health and the Environment

As shown in the human health risk assessments (CDM, 2005, 2008, and 2009), the only significant risk to human health is the consumption of PCB-impacted fish. Risks to human health from exposure via direct contact or ingestion of stream sediment and direct contact or ingestion of stream water were not significant.

DRAFT

The implementation of this alternative would provide a means of reducing the risk to both human health and the environment. Compared to the partial removal alternatives, complete removal of PCB-impacted sediment would provide the greatest degree of risk reduction from exposure to PCBs for both aquatic organisms and terrestrial organisms that feed on aquatic organisms. The risk to human health from consumption of PCB-impacted fish would also be reduced as PCB concentrations are reduced in the food chain; however, complete removal of PCB-impacted sediment provides the greatest degree of habitat destruction, which could be detrimental to fish and other aquatic organisms until the stream and suitable habitat are restored.

5.8.2 Compliance With ARARs

A comprehensive list of federal and state ARARs is presented in Section 2.0 and Appendix E. ARARs are divided into contaminant-specific, location-specific, and action-specific requirements.

There are no state contaminant-specific ARARs for PCBs in stream sediment. Table 2 through Table 5 show that federal contaminant-specific ARARs for PCB remediation waste (Section 3.1.2.1) are not being met in stream sediment. Under the assumptions of the conditions for dry excavation described above for Alternative 7, the post-remediation sediment PCB concentrations would meet the federal chemical-specific ARAR-based PRG of 1 mg/kg (1,000 µg/kg) for PCB remediation waste in high occupancy areas (see Section 3.1.2.1); however, it should be noted that the EPA regional administrator may also require cleanup to more stringent levels based on proximity to areas such as residences, wetlands, fisheries, etc. While not an ARAR, the TMDL target concentration for PCBs in Big Spring Creek of 189 µg/kg is “To Be Considered” (Section 2.0). This concentration is based on the probable effects level developed by EPA (1997). DEQ’s TMDL report calls for the average Aroclor 1254 concentration to be less than 189 µg/kg. The TMDL target concentration would likely be met in the stream sediment after excavation in all subreaches under Alternative 7. Removal of the in-stream sediment would remove the source of PCBs and should result in improvements in PCB concentrations in fish and other aquatic organisms.

The TMDL target concentration for PCBs in fish tissue (<0.025 mg/kg) would likely be met in this alternative provided the dry excavation is thorough and there are no detectable PCBs in sediment following remediation.

Implementation of this alternative is expected to satisfy air quality regulations because disposal of PCB-impacted sediment in a solid waste landfill would stabilize contaminant sources and inhibit fugitive emissions.

Location-specific ARARs are expected to be met in the implementation of this alternative. Contacts with the appropriate agencies and acquisition of required permits related to streambeds, floodplains, and archaeological/paleontological resources would be completed.

Action-specific ARARs are expected to be met including the disposal requirements of TSCA and the hydrological regulations contained in the Strip and Underground Mine Reclamation Act. Temporary stream diversion and in-stream excavation would require coordination with the Montana Department of Fish, Wildlife, and Parks, The U.S. Army Corps of Engineers, the Montana Department of Natural Resources and Conservation, and the Montana Department of Environmental Quality. Revegetation requirements contained in the Surface Mining and Control

DRAFT

Reclamation Act would be met. State of Montana air quality regulations related to dust suppression and control during construction activities would be met using water sprays where applicable, i.e. the excavation area and haul roads with heavy vehicular traffic.

Occupational Safety and Health Administration (OSHA) requirements would be met by requiring appropriate safety training for all on-site workers during the construction phase. Site activities would be conducted under the guidance of a Health and Safety Plan for the site as per OSHA 29 CFR 1910.120. Site personnel would have completed 40-hour hazardous waste operations and emergency response training and would be current on the 8-hour annual refresher training as required by OSHA.

5.8.3 Long-Term Effectiveness and Permanence

This alternative would reduce contaminant mobility at the site by removing the highest risk, solid media contaminant sources and disposing of these wastes in a permitted Class II landfill. PCB-impacted sediment would be encapsulated in a permitted Class II landfill, which would effectively isolate this waste and reduce contaminant mobility. This alternative achieves long-term risk reduction by transporting the contaminated materials to a facility that specializes in the storage and disposal of non-hazardous wastes, thus providing for the long-term permanence of the remedy since point sources of PCBs have been removed from both the upper and lower hatchery. Reliable monitoring results to show reductions in PCBs in fish tissue would take several years to obtain. Rainbow and brown trout in the creek are currently impacted with PCBs. Therefore, it would take an estimated 6 to 8 years for new generations of fish that have not previously been impacted by PCBs to grow to the appropriate size for sampling and accurately reflect the post-remediation PCB concentrations in fish tissue. FWP protocols for monitoring fish in Big Spring Creek include the collection of rainbow trout (13-15 inches total length) and brown trout (14-16 inches total length).

Of the three removal methods, dry excavation provides for the most controlled and thorough removal because it is completed in the absence of flowing water and has little to no chance of resuspending PCBs that could be redeposited in the stream. Because of the complete removal to 36 inches, Alternative 7 provides for the greatest long-term effectiveness and permanence of the seven alternatives.

Removal of the stream sediment to a depth of 36 inches by dry excavation would effectively destroy the aquatic habitat for an estimated 2 to 5 years until stream restoration is completed and sufficient food sources to support a healthy population of aquatic insects is re-established. Fish are expected return to the area after habitat and food sources are restored.

Stream restoration projects have been successfully completed on numerous streams. A period of 2 to 5 years is typically required after construction to re-establish vegetation. Stream restoration is a proven technology if implemented properly, which supports to the long-term effectiveness and permanence of Alternative 7.

DRAFT

5.8.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

Reduction of contaminant mobility is the primary objective of this alternative. The volume and toxicity of the contaminants in the waste materials would not be physically or chemically reduced. The removal of the impacted sediment from the streambed would reduce the contaminant mobility by moving the waste to a secure location. Since the removal would be completed in the absence of flowing water, Alternative 7 should provide for little or no deposition of PCB-laden sediment in the streambed. The dewatered sediment would be encapsulated in permitted Class II landfill, whose physical location is protected from erosion and water infiltration.

5.8.5 Short-Term Effectiveness

It is anticipated that construction activities related to the implementation of this alternative would be completed in one construction season. Impacts associated with construction activities should not significantly impact human health or the environment. On-site workers would be protected by following a site-specific Health and Safety Plan, employing appropriate personal protective equipment and by following proper operating and safety procedures. Short term water quality impacts may occur during installation of stream diversions; however, the use of dry excavation techniques would minimize these impacts compared to both mechanical and hydraulic dredging. Best management practices would be used to control erosion and sedimentation during the remedial action.

Short term air quality impacts to the immediate environment may occur due to the relatively large volume of waste excavation and hauling. The wet nature of the sediment should control fugitive dust; however, dry sediment being stored prior to hauling to the landfill may require the use of water spray to control fugitive dust. The use of heavy equipment and haul trucks, and the need for haul roads, staging areas, and sediment processing areas would impact local residents in the project area during construction activities. Other short-term impacts to local residents would include potential noise and dust from construction activities. Noise can be controlled through the use of set working hours; however, if pumping is selected as the preferred option for diverting water, pumps would be required to run 24 hours per day.

On-site workers would be protected by following a site specific Health and Safety Plan, employing appropriate personal protective equipment, and by following proper operating and safety procedures. However, short term air quality impacts to the immediate environment may occur due to the relatively large volume of waste excavation and hauling. Control of fugitive dust may require the use of water sprays.

Impacts to the surrounding community are expected to be minimal due to the location of the project site. The most significant short-term impact to the surrounding community would involve increased vehicle traffic, particularly haul truck traffic, with associated safety hazards and potential dust generation. A traffic control plan, including warning signs and possibly flaggers, would be required while transporting these wastes.

Direct Effects on Biota. Under Alternative 7, complete removal (upper 36-inches) via dry excavation would be conducted in all subreaches of the upper creek. Dry excavation is considered to be the second most invasive and destructive alternative affecting aquatic life in the stream only next to mechanical dredging, although excavating to the 36-inch depth would be far more invasive than Alternative 4, that involves excavating to a depth of only 6 inches. Removing the upper 36-inches via dry excavation from all subreaches would likely remove all periphyton, rooted aquatic plants, and invertebrates from the creek. Under this alternative, fish would be driven out of the upper section of the creek due to diversion and dewatering of the creek to facilitate dry excavation activities. Fish driven out of the remediated areas would invariably compete for habitat and food with fish inhabiting the other sections of the creek and

DRAFT

could result in reduced growth and even mortality depending on the resource availability and partitioning.

Direct adult and juvenile trout mortality should be low for these mobile organisms. Fish eggs and sac fry found in the gravel during excavation would likely have close to 100% mortality. It would take an estimated 6 months to excavate the entire 2.77 miles, so it is likely the project area would be excavated during the critical spawning and rearing periods. Surveys conducted on Big Spring Creek indicate brown trout spawn between mid-October and late November. Brown trout eggs hatch during the winter and the sac fry probably stay in the gravels until March. Spawning for rainbow trout likely runs from March through May, with swim-up (emergence from the gravels) occurring somewhere between early June and late July. If excavation is postponed until after trout swim-up in June or July, mortality of YOY rainbow trout should be reduced. Length of excavation time and seasonality of excavation may make such time restrictions impractical or require excavation over two seasons. Survival of eggs and fry would not likely occur in the streambed cobbles of riffle crests that are not excavated to preserve stream stability because these areas would be dry during operations. It is unlikely that reproduction from brown trout in the upper 2 miles of Big Spring Creek provides much recruitment to Big Spring Creek; excavation impacts to brown trout reproduction in this reach would likely have little impact on brown trout numbers in Big Spring Creek. However, rainbow trout spawning in the two miles below the lower hatchery may contribute substantially to the rainbow trout population in Big Spring Creek.

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Recolonization. The length of time anticipated for recolonization of fish, invertebrates, rooted aquatic plants, and periphyton to the upper creek under Alternative 7 would likely be the second longest of all proposed alternatives, next to Alternative 5. Unfortunately, the most impacted areas of the creek are near the sources of the creek, leaving only two small tributaries (Hansen and Castle Creeks) that would serve as an upstream source of plants and animals to assist in the recolonization of the excavated portion of the creek.

Fish. Under this alternative, fish would be driven out of the upper section of the creek due to diversion and dewatering of the creek to facilitate dry excavation activities. The length of time required to dry excavate under this alternative would likely overlap the spawning period of both spring spawning rainbow trout and fall spawning brown trout. Impacts to spawning fish likely extend beyond actual physical removal and destruction during excavation by reducing sediment stability until after a high flow period (Harvey and Lisle 1998). Substrate within the creek with have to be re-graded and constructed, so it may take several years for the periphyton, aquatic vegetation, and invertebrates to return to the remediated sections of the creek that would allow fish to recolonize the area in any significant numbers.

Brewery Flats Case Study. From 1998 – 2000, a 2600-foot reach of Big Spring Creek was constructed. It replaced an entrenched “ditch” with a meandering riffle pool stream channel and floodplain. At Brewery Flats, a new artificial gravel bottomed channel was constructed in the dry with a more natural meander pattern. The excavated area on upper Big Spring Creek would not be a new channel. However, the Brewery Flats project can be used to represent how quickly an area depauperate of insects and plants can become home to Big Spring Creek trout. Within one-year adult trout numbers were higher than the 6-year average prior to the project. Adult trout density (≥ 10 inches) increased by 41% and total biomass by 79% in the six years immediately after the project compared to the six previous years. However, small rainbow trout (6 – 9.9 inches) declined by 59% per mile after the project was completed (Tews 2007).

Any alternative that does not have long lasting impacts on stream stability should only have short-term impacts to the trout population. Based on the Brewery Flats example, these impacts could be very short-lived. Less than 10% of Big Spring Creek would be excavated during this project. High trout numbers, and fish displaced downstream, would likely repopulate the upper creek shortly after the project is completed. The risk assessment indicated that risks to trout were insignificant to very low (CDM, 2008).

Invertebrates. Under this alternative, invertebrates would be completely removed from the upper creek. This impact would be similar to what is seen following rotenone treatments used to kill non-native fish from streams. In these studies, invertebrate communities, both taxa richness and abundances, essentially returned to pre-treatment conditions within 2 years (Whelan 2002), although recolonization was evident as soon as several months after the treatments. This same length of time for invertebrate recolonization would be anticipated under this alternative.

Aquatic Plants. Under this alternative, all aquatic plants and seed banks stored in the sediment would be completely removed from the upper creek. Upstream seed sources, albeit limited, would likely begin to re-establish aquatic plants within 2 years following completion of the project. Waterfowl activity and movement, prominent in the creek, may assist in spreading new seeds to the remediated areas. Even so, it may take several years for aquatic vegetation to return to conditions seen prior to excavation actions.

Terrestrial Vegetation. Under this alternative, impacts to the woody plants on both streambanks along the entire length of the upper creek would be damaged or removed due to the need for excavator operators to have adequate range of motion for activities and unimpeded view of the stream. Depending on the extent of damage, vegetation would regain original size and vigor in 2-5 years. The degree of damage under this alternative would be less than the mechanical dredging alternatives, due to the ability of the excavators to conduct some work in the dry stream channel. Impacts would still be greater than with hydraulic dredging.

5.8.6 Implementability

This alternative is both technically and administratively feasible. Water diversion, waste removal, transportation and disposal, and stream restoration are readily implementable using conventional construction techniques. Stream restoration has been successfully completed on numerous streams and is a proven technology, if implemented correctly. Key project components, such as the availability of equipment, construction expertise, and sufficient landfill space, are present and would aid in the timely implementation and successful execution of the proposed project.

5.8.7 Cost

The total present-worth cost for this alternative has been estimated at $9,831,251. The assumptions for used in estimating these costs are presented in Table 24. Table 29 presents the cost details associated with implementing this alternative. The total cost includes the present-worth value of 30 years of annual maintenance and monitoring costs in addition to capital costs.

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Conceptual Design and Assumptions

Dry excavation would be accomplished by using a diversion or series of diversions to reroute the flow in Big Spring Creek while contaminated sediment is excavated and removed from the streambed. The diversions could include pumping and piping, use of a siphon, excavation of a temporary diversion channel, or a combination of these technologies. Sheet piling and coffer dams are frequently used for construction dewatering projects; however, the coarse nature of the sediment (i.e., abundant cobbles in a high percentage of the streambed) is probably not conducive to driving sheet piling. Sometimes a stream is permanently relocated and then sediment is removed from the former stream by dry excavation. Given the ownership patterns and residential setting along this section of Big Spring Creek, it has been assumed that permanent stream relocation is not a viable option. For the purpose of the feasibility study, it is assumed that the stream would be diverted by pumps and piping in 1,500-foot long sections. Eight pumps would be used to pump the 150 cfs flow in Big Spring Creek into 24-inch HDPE pipe. An additional four pumps would be left in standby in case of a pump failure of any of the primary pumps.

Once the flow in Big Spring Creek is diverted, conventional excavation equipment such as hydraulic excavators and off-road haul trucks would be used to remove streambed sediment to a depth of 3 feet. Although this alternative is referred to as “dry excavation”, this term refers to excavation of sediment in the absence of flowing water and does not mean that the sediment would actually be dry. The streambed would most likely be saturated and could have pools of residual standing water or inflow from springs that render the sediment too wet for off-site transportation and disposal. Therefore, lined storage ponds would be required to temporarily store and dewater the sediment. The water would require settlement in ponds or treatment/filtration to remove suspended sediment which could contain PCBs. After treatment, the water would be discharged to Big Spring Creek or land applied.

Additional processing of sediment would include screening/sorting of the sediment to recover oversize material (>1/4 inch), segregating and collecting the fine sediment fraction, and dewatering of the sediment prior to transportation and disposal. The oversize material would be sorted and blended into gradations based on the geomorphic type (i.e., riffle, run, pool, etc.). Supplemental fines (i.e., 1/4-inch minus) would be blended in as necessary to achieve gradations similar to the pre-excavation condition. The blended oversize material would then be returned to the streambed based on geomorphic type and the streambed reconstructed to near the original condition. Streambanks would be left undisturbed to the extent practical; however, equipment access, haul roads, and haul truck traffic would likely necessitate some streambank reconstruction. Similarly, streambank vegetation would be left intact to the extent practical during removal and replacement of streambed material, but some removal and replacement is expected to occur. Vegetation would be replaced with like materials, but not necessarily the same size.

Temporary sediment storage and processing areas would be selected to minimize disturbance to vegetation and developed areas. Relatively flat open areas, such as meadows or pasture areas, would be suitable for sediment storage and processing areas. At the completion of the project, these areas would be graded to the approximate original contour, and seeded with a mixture of native grasses.

The general construction steps for implementing Alternative 7 are as follows:

- site preparation including road improvements and clearing and grubbing;

DRAFT

- preparation of temporary sediment storage and processing (dewatering, screening/sorting, water collection and treatment) areas;
- installation of stream diversions;
- excavation of streambed sediment;
- hauling sediment to temporary staging and processing areas;
- screening of sediment to remove oversize material (material larger than approximately 1/4-inch;
- dewatering of sediment so that free-draining liquids are removed;
- collection and treatment of water and suspended sediment from the dewatering operation;
- monitoring of PCB concentrations and turbidity levels in the treated water;
- discharge of treated water to Big Spring Creek;
- collection and loading of dewatered sediment into trucks and hauling to the landfill;
- sorting the oversize material into gradations based on geomorphic type that approximate the pre-construction condition, including the addition of 1/4-inch minus material;
- hauling the oversize material and placing it back in the streambed;
- restoring the streambed to near the pre-excavation condition;
- removal and reclamation of stream diversions, haul roads, and temporary sediment staging and storage areas; and
- re-establishing vegetation in disturbed areas.

Dry excavation offers the following advantages over other technologies:

- little to no chance of contaminant resuspension since the removal would be completed in the absence of flowing water;
- the sediment would have a lower water content than mechanical and hydraulic dredging;
- the lower water content would result in less sediment dewatering and water treatment than mechanical or hydraulic dredging;
- dry excavation offers the opportunity for more controlled and more thorough removal than mechanical and hydraulic dredging; and
- dry excavation would likely be less destructive to streambank vegetation than mechanical dredging since equipment can operate to a greater extent within the streambed and less on the streambanks.

DRAFT

Disadvantages of dry excavation include:

- risk of overtopping and localized flooding in the event that the diversion fails (i.e., a pump or piping failure, etc.).
- dry excavation removes all sediment regardless of size;
- requires screening/sorting of the sediment to capture and reuse oversize material;
- deeper sediment removal (3 feet) could potentially introduce streambed and/or streambank instability; and
- requires extensive stream reconstruction/restoration.

DRAFT

6.0 Comparative Analysis of Alternatives

This section provides a comparison of the remediation alternatives retained for addressing PCBs in stream sediment in Big Spring Creek from the upper hatchery to the East Fork. The comparison focuses mainly on the following criteria: 1) the relative protectiveness of human health and the environment provided by the alternatives; 2) the long-term effectiveness and permanence provided by the alternatives; and 3) the estimated attainment of ARARs for each alternative. Qualitative comparisons are used to contrast the two threshold criteria of "overall protection of human health and the environment" and "compliance with ARARs" for each alternative. The primary balancing criteria are also compared, although, the evaluation of each of these criteria is very similar due to the technical similarities in the alternatives themselves, with the exception of costs. Table 30 presents a summary of the alternatives with respect to the first eight evaluation criteria.

Alternative 1 - No Action is not considered any further since this alternative would not address any of the human health or environmental concerns raised for the site and would not meet contaminant-specific ARARs.

Three remediation technologies for removing PCB-impacted sediment from Big Spring Creek have been evaluated: 1) mechanical dredging, 2) hydraulic dredging, and 3) dry excavation. The six action alternatives considered implementation of these three technologies under both complete- and partial-removal scenarios. Each partial removal scenario considered two separate partial removal extents. Since all six action alternatives consider the same general response actions (removal and disposal of impacted sediment), there are many similarities among the alternatives even though the removal methods are different. Of the compete removal alternatives retained for the Site, Alternatives 5, 6, and 7 provide a similar degree of overall protection of human health and the environment since all three alternatives provide for complete removal of the contaminated materials from Big Spring Creek. The main difference between Alternatives 5, 6, and 7 is the removal method.

Alternative 5 provides for removal of contaminated sediment via mechanical dredging. This technology is the probably the least effective of the three complete removal alternatives because it has the highest potential for resuspending and redepositing PCB-laden sediment onto the streambed during remediation. Methods used to control suspension and redeposition of PCBs are crucial to the implementation of this alternative. This alternative would also be the most destructive to the streambanks and streambank vegetation because of the proximity of heavy equipment in the stream and the use of haul trucks. Extensive stream reconstruction and restoration of geomorphic types would be required. Preliminary indications from FWP are that Alternative 5 would likely not receive a Stream Protection Act 124 permit because of the potential for resuspending and depositing PCB-laden sediment on the streambed and the degree of habitat destruction. Therefore, Alternative 5 will not be considered for the preferred alternative.

Alternative 6, which provides for complete removal of contaminated sediment via hydraulic dredge employing a cutterhead to get to a removal depth of 36 inches, is considered the second least effective of the complete removal alternatives. While the action of the cutterhead tends to dislodge and suspend fine sediment, the suction provided by the dredged serves to entrain and contain the sediment. This alternative is the least destructive to the streambank and streambank vegetation of the complete removal alternatives since the dredge works entirely within the stream corridor and not on the banks; however, the action of the cutterhead would

DRAFT

tend to dislodge and move larger particles (i.e., cobbles and coarse gravel), which would disrupt the stream habitat and require extensive stream reconstruction and restoration of geomorphic types. Since the coarse-grained sediment remains in the stream, it would be difficult to replace fine sediment with the coarse-grained sediment in an underwater environment. Preliminary indications from FWP are that Alternative 6 would likely not receive a Stream Protection Act 124 permit because of the potential for resuspending and redepositing PCB-laden sediment on the streambed, the degree of disturbance to the streambed, and difficulties in replacing the fine-grained sediment in an underwater environment. Therefore, Alternative 6 will not be considered for the preferred alternative.

Alternative 7, which provides for complete removal of contaminated sediment via dry excavation, is considered the most effective of the complete removal alternatives. Because dry excavation is completed in the absence of flowing water, it is expected to allow more controlled and more thorough removal of PCB-impacted sediment and has little or no chance of resuspension and redeposition of PCB-laden sediment. Because of the requirement for a stream diversion, Alternative 7 does have an increased short-term risk of localized flooding in the event of a diversion failure. This alternative would be destructive to the streambanks and streambank vegetation because of the proximity of heavy equipment in the stream and the use of haul trucks. Extensive stream reconstruction and restoration of geomorphic types would be required. The TMDL target concentration for PCBs in both sediment (189 µg/kg) and fish tissue (<0.025 mg/kg) would likely be met in this alternative provided the dry excavation is thorough and there are no detectable PCBs in sediment following remediation.

The three partial removal alternatives (Alternatives 2, 3, and 4) were divided into two options based on the horizontal extent of removal. The partial removal alternatives considered removing PCB-impacted sediment from the upper 6 inches of the streambed. While the partial removal alternatives would leave PCB-impacted sediment at depths greater than approximately 6 inches, the shallower removal would be less invasive (particularly with suction dredging) and would be less likely to cause streambed and/or streambank instability and habitat destruction. Alternatives 2A, 3A, and 4A consider removal of sediment from the entire length of Big Spring Creek from the upper hatchery to the East Fork (Subreaches 2A through 4B). The implementation of these alternatives would be similar to Alternatives 5, 6, and 7, except for the depth of removal. Alternatives 2B, 3B, and 4B consider the removal of the upper 6 inches of sediment from Subreaches 2A, 2B, and 3A. Removal of sediment from the upper 6 inches of Subreaches 2A, 2B, and 3A would target the sediment with the highest PCB concentrations.

DRAFT

Alternatives 2A and 2B (mechanical dredging) have the same limitation as Alternative 5 in that they have the highest potential for resuspension and redeposition of PCB-laden sediment to the streambed during remediation since the removal takes place in the presence of flowing water. Methods used to control suspension and redeposition of PCBs are crucial to the implementation of this alternative. This alternative would also be the most destructive to the streambanks and streambank vegetation because of the proximity of heavy equipment in the stream and the use of haul trucks. Extensive stream reconstruction and restoration of geomorphic types would be required. Alternative 2 has the same limitation for obtaining a Stream Protection Act 124 permit because of the potential for resuspending and depositing PCB-laden sediment on the streambed and the degree of habitat destruction. Therefore, Alternatives 2A and 2B will not be considered for the preferred alternative.

Alternatives 3A and 3B (plain suction dredging) would provide for removal of a high percentage of PCB-laden fine sediment in approximately the upper 6 inches and would be the least destructive to stream habitat and streambank vegetation of the 6 action alternatives. The use of a plain suction dredge would remove only the fine-grained sediment from approximately the upper 6 inches of the streambed and would likely not require stream restoration. The dredge would operate entirely within the stream corridor. Sediment collection, dewatering, and water treatment equipment could operate away from the stream. Therefore, only a minor amount of streambank vegetation (enough to pass dredge suction hoses) would be disturbed.

Alternatives 4A and 4B (dry excavation) would provide a similar, although lesser degree of benefit as Alternative 7, since they would be completed in the absence of flowing water; however, they would also be destructive to the streambanks and streambank vegetation. Because of the significant effort required to divert the stream, it does not make sense to create this degree of disturbance and only remove a portion of the PCB-impacted sediment. Therefore, Alternatives 4A and 4B will not be considered for the preferred alternative.

Thus, only Alternatives 3A, 3B, and 7 are considered for the preferred alternative. Alternative 3A is expected to meet contaminant-specific ARARs and TBC (TMDL target concentration of 189 µg/kg) in the surface sediment after implementation of this alternative. Conservative analyses considering complete mixing of the surface and subsurface sediment at some time in the future indicate that the 95% UCL of mean PCB concentrations would be reduced by 70 to 97 percent in the most highly-impacted subreaches (2A and 3A), while the 95% UCLs would be reduced from 10 to 60 percent in the other subreaches. The TMDL target concentration of 189 µg/kg would be met in Subreaches 3B, 4A, an 4B, and nearly met in Subreach 2A (197.7 µg/kg). Under the conservative assumptions of complete mixing of surface and subsurface sediment, the TMDL target concentration would not be met in Subreach 2B and 3A; however, these 95% UCLs are skewed by a small number of high PCB concentration samples. PCB concentrations in the upper six inches, where aquatic organisms would have a greater likelihood of exposure, would have much lower PCB concentrations. The TMDL target concentration for PCBs in fish tissue (<0.025 mg/kg) would not likely be met in this alternative given the potential residual level of PCBs in sediment (69 µg/kg) based on observations from the pilot test. However, fish tissue PCB concentrations are expected to decrease, and potentially would fall below 0.12 mg/kg (site-specific risk assessment target), which would allow for some limited consumption of fish.

Under Alternative 3B, the contaminant-specific ARARs and TBC (TMDL target concentration of 189 µg/kg) are expected to be met in Subreaches 2A, 2B, and 3A in surface sediment (upper 6 inches). The 95% UCLs of mean PCB concentrations in the surface sediment in Subreaches 3B and 4B would still exceed the TMDL target concentration. The conservative analyses considering complete mixing of the surface and subsurface sediment at some time in the future indicate that the 95% UCL of mean PCB concentrations would be reduced by 70 to 97 percent in the most highly-impacted subreaches (2A and 3A), while the PCB concentrations in Subreaches 3B, 4A, and 4B would not be reduced. The TMDL target concentration of 189 µg/kg would be met in Subreaches 4A and 4B, and nearly met in Subreach 2A (197.7 µg/kg) and 3B (214.5 µg/kg). Under the conservative assumptions of complete mixing of surface and subsurface sediment, the TMDL target concentration would not be met in Subreach 2B and 3A; however, these 95% UCLs are skewed by a small number of high PCB concentration samples. After sediment removal from the most contaminated areas, it is expected that PCB concentrations would eventually be decreased through dilution and dispersion as clean sediment is deposited in the stream. The TMDL target concentration for PCBs in fish tissue (<0.025 mg/kg) would not likely be met in this alternative given the potential residual level of PCBs in sediment (69 µg/kg) based on observations from the pilot test. However, fish tissue PCB concentrations are expected to decrease, and potentially would fall below 0.12 mg/kg (site-specific risk assessment target), which would allow for some limited consumption of fish.

DRAFT

By comparison of 95% UCL reduction, Alternative 3A is more effective at reducing risk than Alternative 3B since fine-grained surface sediment is removed from the entire project area rather than a portion. Alternative 7 is expected to achieve nearly complete removal of PCBs in the upper 3 feet of sediment, and is expected to comply with contaminant-specific ARARs and the TMDL target concentration. Alternatives 3A, 3B, and 7 should meet action-specific and location-specific ARARs.

Alternative 7 provides for nearly complete removal of PCBs from the stream environment, while Alternatives 3A and 3B provide for only partial removal. Thus, Alternative 7 provides for greater long-term effectiveness and permanence from a contaminant mobility and exposure perspective. However, Alternative 7 also provides the greatest degree of disturbance to the streambed and streambank vegetation. This could potentially lead to stream instability if stream reconstruction and restoration are not adequately completed. Although Alternatives 3A and 3B provide a lesser degree of contaminant removal than Alternative 7, they are the least invasive and provide the least disturbance to the stream environment.

None of the alternatives reduce the toxicity or volume of PCBs. The objective of each alternative is to sever (complete removal alternatives) or reduce (partial removal alternatives) the exposure pathway and to limit the mobility of the PCBs. Limiting contaminant mobility would achieve protection of human health and the environment and would meet applicable ARARs identified for the site. Alternative 7 should sever the exposure pathway by removing a high percentage of PCBs from the stream environment. Alternative 3A provides the next greatest reduction in contaminant mobility and reducing exposure.

On-site workers would be required to have hazardous materials handling training and would be subject to a site-specific Health and Safety Plan for their protection. All three alternative would have short-term impact to the environment, although efforts would be made to minimize the risk by using best management practices. Impacts to the stream habitat would be short-lived for both Alternative 3A and 3B. Alternative 7 would have a longer short-term impact on the stream environment because of the need to remove streambank vegetation to complete the excavation and hauling, and because of the stream reconstruction. Because each of the alternatives would involve removal and haulage of significant volumes of contaminated sediment, localized air quality impacts may occur from fugitive dust emissions. Water sprays would be used to control dust emissions and to minimize dust exposure, as needed.

Alternatives 3A and 3B would be the easiest to implement and require the least amount of equipment and personnel. They require a small amount of equipment (portable dredge and dewatering and water treatment equipment. Although Alternative 7 provides for the most controlled and thorough sediment removal, it is probably the most technically difficult to implement for a variety of reasons. First, the temporary stream diversion would require constant monitoring so that potential problems can be detected and backup pumps initiated before the diversion is overtopped. Overtopping of the diversion could cause localized flooding and could potentially mobilize PCBs. Alternative 7 is also more difficult to implement than Alternative 3A or 3B because of the precision needed to reconstruct the streambed without inducing stream instabilities. The oversized sediment that is removed must be carefully blended to appropriate sediment gradations for each geomorphic type and replaced to the pre-construction conditions.

Because of the health and safety requirements associated with the waste sources, only properly trained and experienced contractors/crews should perform the specified work. Inexperienced contractors and crews would likely prolong the construction phase and may result in increased costs and compromised safety and performance.

DRAFT

Table 30 indicates the estimated total costs associated with each alternative. The no action alternative is not considered feasible because it would not address the identified risks to human health and the environment at the site. Of the action alternatives considered for the site, estimated costs range from $1,487,862 to $2,839,575 for the partial removal alternatives and $5,353,594 to 12,192,561 for the complete removal alternatives. The estimated present worth costs for Alternatives 3A, 3B, and 7 are $2,839,575, $1,586,593, and $9,831,251, respectively. Alternative 7 is roughly 3 to 6 times more costly than Alternatives 3A and 3B. Thus, even though Alternative 3A and 3B are considered less effective in the long-term because of the potential for eventual mixing subsurface and surface sediment, these alternatives could be implemented multiple times (i.e., every 10 or 20 years if conditions deteriorated) and still be more cost effective than Alternative 7.

Preliminary public input received at two meetings held by FWP with landowners and the PCB advisory committee, and from a written survey complete by the majority of landowners in the project area indicated that the public was opposed to alternatives that included mechanical dredging or dry excavation because of the degree of disturbance to the stream. There was support for hydraulic dredging from most of the landowners and some proponents of no action. There was no expressed support for complete removal alternatives.

DRAFT

7.0 Preferred Alternative

Based on the conclusions of the detailed analysis and the comparative analysis of alternatives, Alternative 3A: Partial Removal of PCB-Impacted Stream Sediment Via Hydraulic Dredge from Subreaches 2A-4B with Disposal at a Solid Waste Landfill is proposed as the preferred alternative for remediation of the Site. This alternative is considered the most appropriate and cost-effective means to reduce risk to human health and the environment to an acceptable level. In summary, the strategy for Alternative 3A involves removing the fine-grained PCB-impacted sediment (approximately 1/4-inch minus) from the upper 6 inches of the Big Spring Creek streambed and disposing of this material in a permitted Class II municipal solid waste landfill. The nearest disposal facility is the Montana Waste Systems High Plains Landfill in Great Falls, Montana, which is permitted for Class II solid wastes.

The volume of sediment in the upper 6 inches is approximately 11,830 CY. Based on particle size analyses, paint chips have been observed in the fraction of sediment finer than 1/4 inches. Approximately 42 percent of the sediment by weight is finer than 1/4 inches. Therefore, the disposal volume is estimated at approximately 5,000 CY and the disposal weight is material is estimated at 8,720 tons.

Dewatering of sediment and treatment of the slurry water could be accomplished by a variety of methods including settling ponds, geotextile tubes, or commercially available treatment systems. The following describes a commercially available system that has been used to treat dredge slurry from other PCB cleanup projects. Dredge slurry could be pumped into a series of filter boxes to dewater the sediment. A filter box is a 25 cubic yard metal box that is lined with a geotextile filter fabric. The geotextile filter fabric retains the sediment, while allowing the water to drain. The sediment retained on the filter fabric is then recovered from the filter box and segregated for disposal. Sediment that is allowed to drain in a filter box should pass the “paint filter test”, which is the standard used to determine if free-draining liquids are present. Solid waste landfills cannot accept wastes with free-draining liquids.

Water and suspended sediment that pass through the filter fabric would be collected in the base of the filter box and treated prior to being discharged back into Big Spring Creek. The water could be treated in a number of ways. A common method is a multi-stage process of settling and filtration. Chitosan, a flocculant derived from crustacean shells (crab, shrimp, and lobster), can be added to the water and suspended sediment mixture to decrease the settling time for colloidal particles if necessary. After passing through a settling tank, the water could then pass through sand filters and be “polished” through a series of bag filters (i.e., 25 micron, 5 micron, and 1 micron) as necessary to achieve water quality standards for PCBs and turbidity prior to discharging the water back into Big Spring Creek.

Since filter boxes, settling tanks, and filtration system components are relatively portable, it is assumed that the impact to property where dewatering and water treatment occurs would be relatively minor and would consist of small disturbances to grassy areas and the presence of tire tracks. These areas would be graded and reseeded as necessary to return the properties to pre-construction conditions. Impacts to the streambanks are expected to be minimal since the dredging activities would take place from within the streambed and sediment dewatering and water treatment activities would take place away from the stream.

Since the preferred alternative would remove only a portion of the sediment (i.e., fine sediment from the upper 6 inches), there is a degree of uncertainty related to the residual PCB

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concentrations in stream sediment and fish tissue. It is expected that removal of PCBs from the surface sediment will result in reductions in PCBs in tissue of fish tissue and other aquatic and terrestrial biota; however, the degree of reduction would not be known until after the remedy is implemented and monitoring has been completed. Reliable monitoring results to show reductions in PCBs in fish tissue would take several years to obtain since rainbow and brown trout in the creek are currently impacted with PCBs. It would take an estimated 6 to 8 years for new generations of fish that have not previously been impacted by PCBs to grow to the appropriate size for sampling to accurately reflect the post-remediation PCB concentrations in fish tissue. FWP protocols for monitoring fish in Big Spring Creek include the collection of rainbow trout (13-15 inches total length) and brown trout (14-16 inches total length).

A monitoring plan would be developed to measure the success of the remedy. The monitoring plan would include the sampling and analyses protocols, the sample locations, the monitoring frequency, the duration of the monitoring (i.e., how many years), benchmarks for measuring the success of the remedy, and mitigation procedures if the benchmarks are not met.

DRAFT

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